National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative

Applied Research STEM Curriculum Portfolio

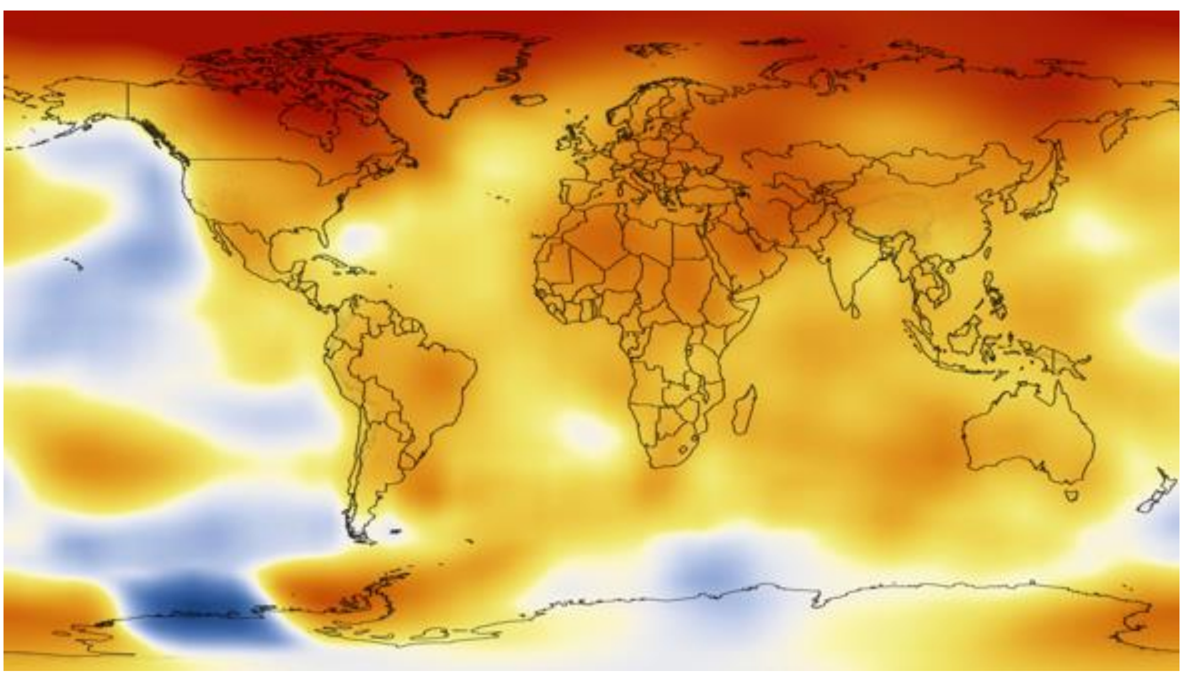
NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

Unit Title: **Blue Carbon:** *Bringing Field Research and ArcGIS Mapping to the High School Classroom*

Overarching Investigative Research Question: How much blue carbon is currently stored in the tidal marshes of the Hudson River estuary? How much may be released if current rates of development and land conversion continue?

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



I. Executive Summary

Coastal wetlands, such as salt marshes, mangroves, and tidal freshwater wetlands provide a variety of ecosystem services. They have the capacity to be a major sink of greenhouse gases since they store carbon in plant biomass, they are a source of great biodiversity, and serve as nurseries to a myriad of fish and other organisms. Wetlands also protect our coasts and serve as natural water filtration systems. They are, however, susceptible to human exploitation. They are threatened by agriculture, drainage, commercial development, and climate change.

This unit has been aligned with NASA's mission to expand our knowledge and scientific understanding of Earth as a system and its response to natural and human-induced changes and to improve our ability to predict climate, weather, and natural hazards. The lessons are intended to provide students with background information on the importance of salt marshes as ecosystems, emphasizing the ecosystem services they provide as well as their intrinsic value. Specifically, students are taking a deeper look at blue carbon, the carbon that is stored largely in sediment linked to coastal waters. Literature and data review are incorporated in order to give students firsthand experience reading, analyzing and presenting actual scientific research. This would then be the impetus to have students create their own methods and protocols to design an experiment to probe for depth at a local saltmarsh or tidal freshwater marsh. The rationale behind this is that students have a stake in the process and ownership of the design. Finally, the culmination of this unit is in having students utilize ArcGIS to map local wetlands, compare and contrast wetland loss over time, and to conduct computational and applied mathematics. Students then take data collected out in the field and work with ArcGIS to calculate carbon storage of the local wetland. An alternative capstone project is included for a virtual environment where students can create their own ArcGIS Blue Carbon Story Map, researching and mapping a wetland from their home country or of significance to them. This project serves three purposes—to emphasize the global importance of wetlands, international efforts towards conservation, and to also celebrate student diversity and inclusion.

II. Table of Contents

Table of Contents

III. NGSS and Common Core Alignment

Grade Band	High School (grades 10-12)
Unit Duration	4 weeks
Sphere	Biosphere & Atmosphere
Phenomena	Cycling of Carbon Urban Heat Islands
NGSS Disciplinary Core Ideas	Ecosystems: Interactions, Energy, and Dynamics Earth's Systems Earth and Human Activity
NGSS Science and Engineering Practices	o Asking questions o Developing and using models o Planning and carrying out investigations o Analyzing and interpreting data o Using mathematics and computational thinking o Constructing explanations and designing solutions o Engaging in argument from evidence o Obtaining, evaluating, and communicating information
NGSS Crosscutting Concepts	Patterns Cause and Effect Systems and System Models Stability & Change
Supported NGSS Performance Expectations	o Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. o Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity o Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
Supported Common Core ELA	o Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account o Draw evidence from informational texts to support analysis, reflection, and research o Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to

	enhance understanding of findings, reasoning, and evidence and to add interest
Supported Common Core Math	o Reason abstractly and quantitatively o Model with mathematics o Define appropriate quantities for the purpose of descriptive modeling o Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

IV. CCRI Teacher Biography

Carol Wang-Mondaca currently teaches Science Research at Martin Van Buren High School (MVBHS) in Queens, NY. She did not start her career path in teaching, however. Carol was an Editor of Medicine for a large scientific publishing company for many years. Then one day, while riding the subway, she saw an ad that read "Do you remember your third grade teacher's name? Who will remember yours?" That sparked something in her that day and she proceeded to join the NYC Teaching Fellows. While teaching was not her first career, her love for science and investigation has been a constant throughout her life. Carol has been teaching for 16 years, and her goals have always been constant- to inspire our future generation to love and pursue science. She loves working with underrepresented and underserved groups. In the summer of 2018, she was awarded an Earthwatch Kindle Fellowship that allowed her and 7 other NYC public school teachers to go to Little Cayman to study endangered coral reefs. She saw firsthand the result of climate change on the bleaching of coral reefs and the surge in algae that appeared. This trip reignited her passion for research in the field and reinforced her urgency to educate our future minds in climate change. In fact, in the Spring of 2019, she took 10 students on a research expedition to the Wrigley Marine Science Center, University of Southern California to participate in studies that look at how climate change has affected marine life along the Catalina coast. By joining the CCRI team on Climate Change in the Hudson Estuary, she is hoping to incorporate NASA resources throughout the year in a new Science Research class that focuses on environmental studies. In March 2020, with Carol leading the school team, MVBHS hosted a NASA In-Flight Education Downlink where students connected with astronaut Jessica Meir aboard the space station for a live question-and-answer session about living and working in space. This is Carol's second year in CCRI and on Dr. Peteet's team.

V. NASA Education Resources Utilized in Unit

1. i.e. NASA Science Activation Learner Resources

- https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/NASA-SciAct-Resource-Handout-11-23-2018%3DTAGGED.pdf
- Recall the carbon cycle https://nasaeclips.arc.nasa.gov/video/launchp/real-world-the-carbon-cycle-essential-for-life-on-earth
- Real World: The Carbon Cycle - Essential for Life on Earth https://nasaeclips.arc.nasa.gov/video/realworld/real-world-the-carbon-cycle-essential-for-life-on-earth
- GLOBE https://www.globe.gov/ru/home

2. Next Gen STEM Resources: https://www.nasa.gov/stem/nextgenstem/index.html https://www.nasa.gov/stem/nextgenstem/moon_to_mars/mars2020stemtoolkit
    - Connect students to countdown to Mars.
        - Connect astrobiology astrobiology questions about the potential for life on Mars with K-12 curricula
        - https://astrobiology.nasa.gov/education/alp/if-a-planet-can-have-life/

3. Resource Titles, descriptions, web address

Lesson 1: Importance of wetlands and what is Blue Carbon

a) Where the wetlands are: https://cdn.earthdata.nasa.gov/conduit/upload/5898/NASA_SOP_2016_where_the_wetlands_are.pdf

b) NASA on Mangroves Video. NASA's Land Cover and Land Use Change program, Simard and his team have developed new remote sensing techniques to monitor the health of mangrove ecosystems https://www.youtube.com/watch?time_continue=24&v=RjSTKItUUX0

c) NASA on Saltmarshes. The importance of Monitoring Wetlands. https://youtu.be/pJJBIeA7ExM

d) A breathing planet off balance
https://www.youtube.com/watch?time_continue=95&v=xk11DVaAjEA&feature=emb_logo
NASA Climate Change. Carbon dioxide emissions from burning fossil fuels and earth's land and water absorb about half of all the carbon dioxide emissions.

e) Climate change and sea level rise
https://www.youtube.com/watch?v=cXzfOpZSmk8
NASA Climate Change. As human activity warms the planet, the oceans absorb more heat, this increases water volume and melts ice caps and glaciers, contributing to sea level rise. Wetlands are at risk as a result of sea level rise.
https://climate.nasa.gov/climate_resources/144/video-how-global-warming-stacks-up/

https://climate.nasa.gov/vital-signs/sea-level/

f) Recall the carbon cycle
https://nasaeclips.arc.nasa.gov/video/launchp/real-world-the-carbon-cycle-essential-for-life-on-earth

Lesson 2: Blue Carbon: NASA Carbon Monitoring System

a) US Global Change Research Program. Supported by and coordinated among 13 federal agencies, including NASA, on understanding the forces shaping the global environment, both human and natural, and their impacts on society. One of its goals is to advance understanding of the changing Earth system and maximize efficiencies in Federal global change research.
www.GlobalChange.Gov

b) NASA's Global Climate Change Vital Signs of the Climate that provides facts, articles, solutions and resources for students (and teachers) to further explore
https://climate.nasa.gov

c) NASA's Climate Change and Ecosystems website that provides current information, such as the current ECOSTRESS mission
https://cce.nasa.gov/cce/index.htm
https://cce.nasa.gov/biodiversity/about.html

d) Real World: The Carbon Cycle - Essential for Life on Earth

Carbon is an essential building block for life. Learning how carbon is converted through slow- and fast-moving cycles helps us understand how this life-sustaining element moves through the environment. Discover how NASA measures carbon through both field work and satellite imagery keeping watch through its eyes on the sky, on Earth, and in space. https://nasaeclips.arc.nasa.gov/video/realworld/real-world-the-carbon-cycle-essential-for-life-on-earth

e) NASA's Carbon Monitoring Website
carbon.nasa.gov

f) United States Carbon Cycle Science Program is an interagency partnership that coordinates and facilitates activities relevant to carbon cycle science, climate and global change
https://www.carboncyclescience.us/

Lesson 3: Urban Heat Island Effect
Urban Heat Island Effect

a) https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects

b) https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation

c) ArcGIS StoryMaps
Mapping Urban Hotspots using NASA Earth Observations in New York City
https://storymaps.arcgis.com/stories/a8f232ac363f499d88a64fb0f8b226a9

d) NASA Urban Heat Islands
https://www.youtube.com/watch?v=s9tMC_80qRQ

e) Creation of Urban Heat Islands (teacher background information resource)
https://www.arcgis.com/apps/MapSeries/index.html?appid=44b9c8738f0e47e68d9e8ae2c530ed08

Lesson 4: Surface temperature

a) Following GLOBE protocols and uploading surface temperature data collection to GLOBE database.

www.globe.gov
Teacher Guide:
https://www.globe.gov/documents/2981444/3462601/STFC-TeacherParticipationGuide.pdf

Surface Temperature Protocol
https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

Lesson 5: Capstone: Bringing it all together—how much carbon is there?

How NASA uses GIS
https://earthdata.nasa.gov/learn/gis

https://lpdaac.usgs.gov/data/get-started-data/

https://maps.nccs.nasa.gov/arcgis/apps/webappviewer/index.html

VI. Data visualization & analysis activities

Students will conduct probing of soil to find depth of saltmarshes. They will be using Google Earth and then ArcGIS to perform mapping and visualization of saltmarsh areas to calculate the potential blue carbon stored in the sampled areas. They will learn and implement GLOBE protocols for conducting surface temperature analysis and upload their data to GLOBE. In Lesson 5, culminating in the students' capstone project, students will be designing their own probing protocols and using various depths of the marsh, determining blue carbon content. They will then relate this data collection to determine how human impact on the saltmarsh ecosystem would impact carbon storage. The capstone project will highlight their data collection, analysis and presentation skills. The students must be able to not only present their data but speak to it so that their peers, who have little background knowledge of their research, will be able to understand their findings and significance.

Via globe.gov, students will contribute to the global research data when they upload their data collection, following GLOBE protocols.

VII. NASA Office of STEM Engagement Mission, Vision, Strategic Goals and Objectives alignment

This unit plan has integrated the vision and mission of the NASA Office of STEM Engagement to immerse the public in NASA's work, enhance STEM literacy, and inspire the next generation to explore. Using authentic learning experiences whereby students are out in the field, doing hands on work and then bringing that data back into the lab for analysis and using NASA imaging techniques is paramount to achieving these goals. The unit is also aligned with NASA's mission to highlight diversity and inclusion by relating the work to each student's interest and celebrating their background in the ArcGIS Story Map lesson. This unit plan speaks to a diverse groups of students and attracts them to STEM through learning opportunities that spark interest and provide connections to NASA's mission and work. It is aligned with the objective to provide authentic learning experiences with NASA's content.

VIII. NASA Mission Alignment

https://www.nasa.gov/missions

According to NASA's Mission Directorates and Center Alignment, specifically regarding the Earth Science division, its mission is to advance our scientific understanding of Earth as a system and its response to natural and human-induced changes and to improve our ability to predict climate, weather, and natural hazards. This lesson plan unit clearly is aligned to this aspect of NASA'S mission as we investigate wetland ecosystems and how fragile they are in response to climate change. Our hands-on fieldwork to determine the depth of the marshes and therefore the total carbon content of Alley Pond marsh will help us understand how disrupting these wetlands would have a significant impact on carbon released into the atmosphere, thereby exacerbating climate change.

IX. NASA Strategic Objective Alignment

https://www.nasa.gov/sites/default/files/atoms/files/nasa_2018_strategic_plan.pdf

This unit plan is aligned with NASA's strategic goal 3—to address national challenges and catalyze economic growth. NASA gathers climate change data and engages and inspires young people to become scientists through this project. Attracting students to enter STEM fields is vitally important and is a component of its strategic goals. Therefore, strategic objective 3.3 sets to inspire, engage and educate and employ the next generation of explorer through NASA-unique STEM learning opportunities. By using NASA resources and drawing on the research of Dr. Peteet, this unit plan would fulfill this objective. This strategic objective includes proactive efforts to diversify the STEM pipeline to NASA internships and employment and increase the number of underrepresented and underserved groups in the STEM fields, including girls in STEM and minority groups.

X. NASA SMD Decadal Survey Alignment

https://science.nasa.gov/earth-science/decadal-surveys
https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth

This unit aligns with NASA SMD Decadal Survey in its focus on ecosystems. Specifically, it aligns with goals of quantifying the distribution of the functional traits, functional types, and composition of vegetation and marine biomass, spatially and over time, listed as one of the most important priorities in its study on surface biology and geology. Also listed as most important is quantifying the physiological dynamics of terrestrial and aquatic primary producers as the unit investigates human impact on wetlands. Quantifying carbon dioxide between land ecosystems and atmosphere and between ocean ecosystems and atmosphere is demonstrated in the unit's focus on blue carbon. One of the aspects listed as important is on climate and the quantifying carbon dioxide fluxes and explaining variability by net uptake of carbon by terrestrial ecosystems.

XI. Unit pre-and post-standards-based assessment with answer key

Introduction to the Wetlands and Blue Carbon: Baseline assessment (and post-assessment)

Directions: Answer the following questions to the best of your ability.

1. What are wetlands? (5)

2. What are three economic and/or ecological services that wetlands provide? (3 pts each)

3. Where can you find saltmarshes in the United States? (5)

4. How have humans impacted wetlands and what are the results? Describe at least 3. (3 pts each)

5. What is eutrophication? (5)

6. What is run off? (5)

7. Why would nitrogen levels increase as human population increases in an area? (5)

8. What is soil organic matter? (5)

9. When conducting an experiment, what is the first step the scientist must take? (5)

10. How do we record our data? (5) How can we organize our data for analysis? (5)

11. List 5 things that we are not allowed to do in the lab. (1 point each)

12. What is surface temperature? (5 points)

13. What instrument do we use to measure surface temperature? (3 points)

14. Name two factors that affect surface temperature (2 pts each)

15. What is the Urban Heat Island Effect? (10 points)

16. What is a transect? (5 points)

17. What instrument do we use to determine the depth of a saltmarsh? (5 points)

18. How do we calculate total carbon? (5 points)

Introduction to the Wetlands and Blue Carbon: Baseline assessment (and post-assessment)

ANSWER KEY

A grade below 58 is considered below grade level.
A grade of 58-64 is approaching grade level.
A grade of 65-79 is considered at grade level.
A grade of at least an 80 is considered mastery.

Directions: Answer the following questions to the best of your ability.

1. What are wetlands? (5 pts)
   Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year

2. What are three economic and/or ecological services that wetlands provide? (3 pts each)

   Wetlands provide habitats for thousands of species of aquatic and terrestrial plants and animals. Wetlands are valuable for flood protection, acting as a buffering system, water quality improvement by filtering the water, shoreline erosion control. Wetlands provide economic services such as natural products, recreation, and aesthetics for humans.

   Wetlands are among the most productive habitats on earth providing shelter and nursery areas for commercially and recreationally important animals like fish and shellfish, as well as wintering grounds for migrating birds. Coastal marshes are particularly valuable for preventing loss of life and property by moderating extreme floods and buffering the land from storms; they also form natural reservoirs and help maintain desirable water quality

3. Where can you find saltmarshes in the United States? (5 pts)
   In the US, saltmarshes can be found on every coast. Approximately half the nation's saltmarshes are found along the Gulf Coast. We have one in Alley Pond Park!

4. How have humans impacted wetlands and what are the results? Describe at least 3. (3 each)

   Saltmarsh habitats have been damaged by humans from agricultural draining, oil spills, run off, and pollution. Salt marshes in urban watersheds may receive enormous volumes of stormwater runoff, which can lead to increased erosion, sedimentation, altered salinity levels, and changes in soil saturation levels

As a result, there is a decrease in biodiversity and ecological services that the saltmarshes can provide. Climate change and sea level rise have also threatened saltmarshes. By building road through saltmarshes, we are also cutting off the water supply from the ocean. Additionally, the introduction of invasive species could potentially alter the native populations of plants and animals.

5. What is eutrophication? What results from anthropogenic eutrophication? (5 pts)
   Eutrophication results from and increased load of nutrients to coastal waters and estuaries. This causes harmful algal blooms and low oxygen waters that can kill fish and seagrass and reduced essential fish habitats. The increased load in nutrients (phosphorous and nitrogen) usually comes from agriculture.

6. What is agricultural run off? (5 pts)
   Farmers apply nutrients on their fields in the form of chemical fertilizers and animal manure, which provide crops with the nitrogen and phosphorus necessary to grow and produce the food we eat. However, when nitrogen and phosphorus are not fully utilized by the growing plants, they can be lost from the farm fields. This excess nitrogen and phosphorus can be washed from farm fields and into waterways during rain events and when snow melts, and can also leach through the soil and into groundwater over time.

7. Why would nitrogen levels increase as human population increases in an area? (5 pts)
   Nitrogen is found in waste and is also used in agriculture. Therefore, as human population increases, the levels of nitrogen would increase with increased farming to sustain the population and as a result of sewage.

8. What is soil organic matter? (5 pts)
   Soil organic matter is the fraction of soil that consists of plant or animal tissues in various stages of decomposition.

9. When conducting an experiment, what is the first step the scientist must take? (5 pts)
   A scientist must first pose a question.

10. How do we record our data? How can we organize our data for analysis? (5 pts)
    Data is recorded in tables and graphs help us visualize the data for analysis.

11. List 5 things that we are not allowed to do in the lab. (1 point each)
    We are not allowed to eat, drink, chew gum, wear open toed shoes, wear shorts or short skirts, leave long hair undone, go without a lab coat, leave unlabeled bottles/flasks/beakers/containers laying around, taste or drink any chemicals and reagents.

12. What is surface temperature? (5 points)
    Land surface temperature is how hot the "surface" of the Earth would feel to the touch in a particular location. From a satellite's point of view, the "surface" is whatever it sees when it looks through the atmosphere to the ground. It could be snow and ice, the grass on a lawn, the roof of a building, or the leaves in the canopy of a forest. Thus, land surface temperature is not the same as the air temperature that is included in the daily weather report.

13. What instrument do we use to measure surface temperature? (3 points)
    Infrared Temperature (IRT) gun

14. Name two factors that affect surface temperature (2 pts each)

    Students answers may vary. Several factors can fundamentally influence the derivation of LST including:

    - temperature variations with angles
    - sub-pixel in-homogeneities in temperature and cover
    - surface spectral emissivity at the channel wavelengths
    - atmospheric temperature and humidity variations
    - clouds and large aerosol particles such as dust.

15. What is the Urban Heat Island Effect? (10 points)
    An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The difference in temperature between urban and less-developed rural areas has to do with how well the surfaces in each environment absorb and hold heat. Materials used in building such as asphalt, steel, and brick are often very dark colors—like black, brown and grey. A dark object **absorbs** all wavelengths of light energy and converts them into heat, so the object gets warm. In contrast, a white object **reflects** all wavelengths of light. Also, urban building materials are impervious, which means that water can't flow through surfaces like a brick or a patch of cement like it would through a plant. Without a cycle of

flowing and evaporating water, these surfaces have nothing to cool them down.

16. What is a transect? (5 points)
    A transect is a line across a habitat or part of a habitat

17. What instrument do we use to determine the depth of a saltmarsh? (5 points)
    A probe

18. How do we calculate total carbon? (5 points)
    Area x average depth x LOI x organic percentage

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CCRI Unit Plan Template

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Unit Title: Blue Carbon
Bringing Field Research and ArcGIS Mapping to the High School Classroom

Lesson 1: ***Introduction to wetlands and blue carbon***

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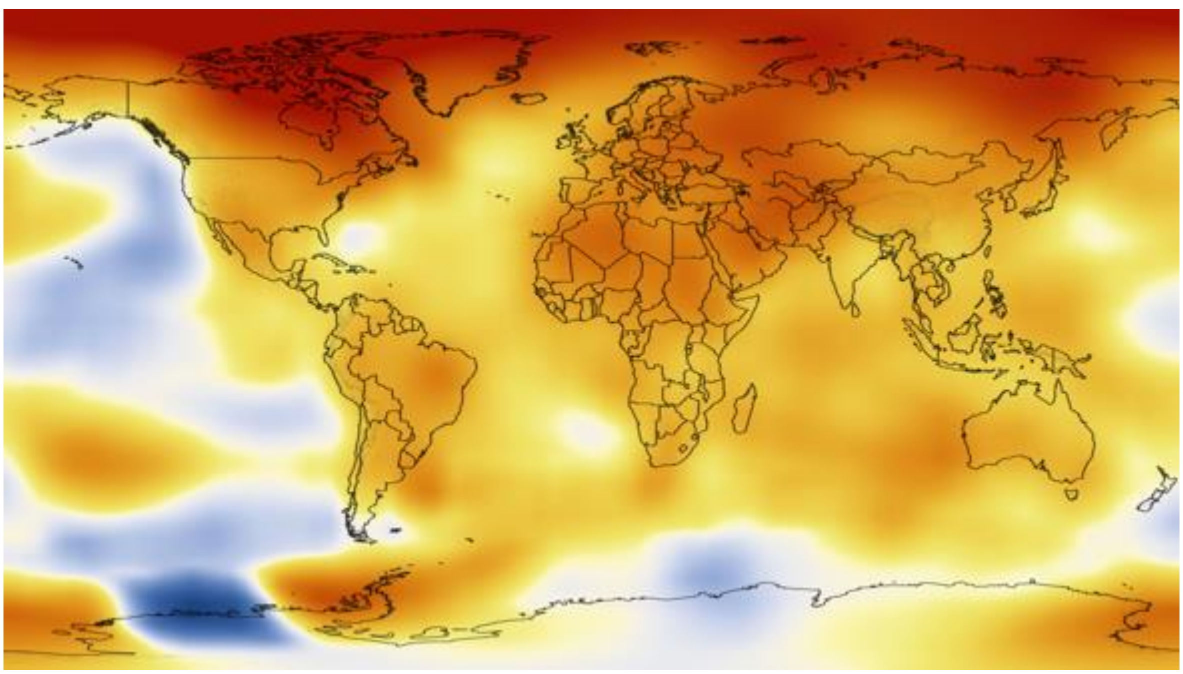


XII. Lesson 1: Title Introduction to wetlands and blue carbon

1. Table of Contents for lesson

2. Summary and Goals of Lesson

This lesson will introduce students to the importance of wetlands, including how they are defined and the different types of wetlands that exist. Students will begin to have an understanding of the ecosystem and economic services that wetlands provide. Students will understand the impact humans have had on the wetland ecosystems. Students will also use Google Earth Engine case studies and other NASA resources to observe the results of climate change on sea level rise and the subsequent impact on marshes and mangroves.

Students will also be introduced to Blue Carbon and its importance as a source of carbon storage in coastal and marine ecosystems.

3. CCRI Lesson Plan Content Template

NGSS Standard: HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. **Phenomenon:** Cycling of carbon **Crosscutting concepts:** Patterns Cause and Effect Systems and System Models Stability & Change			Common Core Standard: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	NASA Science: Earth Science
Content Area: Environmental Science Grade Level: 11 & 12 grade		Name of Project-Based Activity or Theme: Understanding economic and ecosystem services of wetlands and the importance of Blue Carbon	Estimated Time Frame to Complete Lesson: 3 days	
Overall Investigation Question(s): How can we investigate the importance of wetlands in their economic and ecosystem services?				
Overall Project Description/Activity: View NASA video clips on Saltmarshes and Mangroves. Students will understand the economic and ecosystem services that wetlands provide as well the biodiversity exhibited in these ecosystems. Students will extend that knowledge to understand the concept of blue carbon.				
Materials Needed to Complete Project	Stakeholders:	Hyperlinks Used:	Multimedia/Technology:	Classroom Equipment:
	Students, teacher, administrator	NASA on Mangroves https://www.youtube.com/watch?time_continue=24&v=RjSTKItUUX0 NASA on Saltmarshes https://youtu.be/pLlu2WiU-z8 Where the wetlands are https://earthdata.nasa.gov/learn/sensing-our-planet/where-the-wetlands-are Blue carbon Initiative https://www.thebluecarboninitiative.org/ NASA Carbon Monitoring System	Smartboard, computer	smartboard

		carbon.nasa.gov/ A breathing plant off balance https://www.youtube.com/watch?time_continue=95&v=xk11DVaAjEA&feature=emb_logo Climate change and sea level rise https://www.youtube.com/watch?v=cXzfOpZSmk8 https://climate.nasa.gov/climate_resources/144/video-how-global-warming-stacks-up/ https://climate.nasa.gov/vital-signs/sea-level/ Recall the carbon cycle https://nasaeclips.arc.nasa.gov/video/launchp/real-world-the-carbon-cycle-essential-for-life-on-earth Pictures of wetlands https://www.giss.nasa.gov/research/briefs/matthews_02/ Enrichment: What determines if a planet can have life (Moon to Mars)? https://astrobiology.nasa.gov/education/alp/if-a-planet-can-have-life/ The Mars 2020 Perseverance Rover will search for signs of ancient microbial life, which will advance NASA's quest to explore the past habitability of Mars. The rover has a drill to collect core samples. https://mars.nasa.gov/mars2020/mission/overview/		
NASA System Engineering Behaviors: (1 behaviors per category)	Category (must have one Technical Acumen)	Activities: How will students model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes: How will you assess learning for each behavior	Evaluation: Describe specific science content students understand as a result of engineering behavior.
Communicates effectively through personal interaction	Communications	Students work in groups to compare and contrast the various types of wetlands.	Works cooperatively with teammates	Students are able to work in groups to compare and contrast the various types of wetlands.
Builds Team Cohesion	Leadership	Students work in groups and exhibit shared responsibility	Works cooperatively with teammates	Students are able to work in groups to compare and contrast the various types of wetlands.
Seeks information	Attitudes & Attributes	Students ask questions.	Utilizes the resources given and also uses	Students ask how humans can

and uses the art of questioning			internet searches to help each other	decrease their footprint on wetlands
Remains open minded and objective	Systems Thinking	Students brainstorm why characteristics of wetlands make the, susceptible to exploitation and harm.	Is willing to adjust answers and identifications as new information rises	Students can brainstorm ideas as to how we can minimize our impact
Learns from success and failures	Technical Acumen	Students are willing to revisit their answers to expand on them	Is willing to adjust answers	Students ask how humans can decrease their footprint on wetlands
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes	List Attached Documents (if any): PPT on Wetland Intro and Blue Carbon Handout and Exit slip on economic and ecological services of wetlands HW on NASA Carbon Monitoring System		

4. Mission Alignment

The lesson is aligned with the Landsat Program, which provides the longest continuous space-based record of Earth's land existence.

5. Time to implement lesson: 3 days

4. Materials required

- NASA resources
  - o NASA on Mangroves
    https://www.youtube.com/watch?time_continue=24&v=RjSTKItUUX0
  - o NASA on Saltmarshes
    https://youtu.be/pLlu2WiU-z8
  - o Where the wetlands are
    https://earthdata.nasa.gov/learn/sensing-our-planet/where-the-wetlands-are
  - o Blue carbon Initiative
    https://www.thebluecarboninitiative.org
  - o NASA Carbon Monitoring System
    https://carbon.nasa.gov/
  - o A breathing plant off balance
    https://www.youtube.com/watch?time_continue=95&v=xk11DVaAjEA&feature=emb_logo
  - o Climate change and sea level rise
    https://www.youtube.com/watch?v=cXzfOpZSmk8
    https://climate.nasa.gov/climate_resources/144/video-how-global-warming-stacks-up/
  - o Recall the carbon cycle
    https://nasaeclips.arc.nasa.gov/video/launchp/real-world-the-carbon-cycle-essential-for-life-on-earth
  - o Pictures of wetlands
    https://www.giss.nasa.gov/research/briefs/matthews_02/
- PPT on Wetland Intro and Blue Carbon
- Handout and Exit slip on economic and ecological services of wetlands
- HW on NASA Carbon Monitoring System

5. 5 E lesson model template:

Lesson Title: Why are wetlands essential in the ecosystem and economic services they provide?
Grade Level: 11th and 12th graders
Duration: 3 days

	What the Teacher Does	What the Students Do	Duration
Engage: **pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.**	Show students pictures (https://www.giss.nasa.gov/research/briefs/matthews_02/) of a local wetland. Explain that this is a wetland, right in their own backyards. Using the illustrations, elicit characteristics of wetlands that students can then use to define what wetlands are. To modify this lesson for any wetland in any area, teachers can go to the Wetlands Mapper, https://www.fws.gov/wetlands/data/Mapper.html, which is a part of the National Wetlands Inventory provided by the US Fish and Wildlife Service. Teachers can find local wetlands nearby their school for a daytrip. Additionally, the National Environmental Education Foundation lists United Wetlands by state (https://www.neefusa.org/nature/land/wetlands-united-states, which links back to the US Fish and Wildlife Service with specific wetlands in that	Students note down characteristics and observations. Students define what they think wetlands are.	15 mins

	state. The site provides highlights of what fauna and flora are found in each of the wetlands.		
Explore: **The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.**	Present the different types of wetlands. Explain the commonalities among them as well as their differences. (for reference, NASA defines types of wetlands: https://www.hq.nasa.gov/iwgsdi/Wetland.html)	Students watch the NASA videos on Mangroves and Saltmarshes (NASA on Mangroves https://www.youtube.com/watch?time_continue=24&v=RjSTKItUUX0 NASA on Saltmarshes https://youtu.be/pLlu2WiU-z8 Where the wetlands are https://earthdata.nasa.gov/learn/sensing-our-planet/where-the-wetlands-are) (videos also embedded within PPT), jotting down the specific characteristics, comparing and contrasting them both	30 minutes
Explain: **Provide students with an opportunity to communicate what they have learned so far and figure out what it means.**	Allow students to assemble in groups to discuss the characteristics of wetland ecosystems. They are also instructed to discuss possible ways in which these features make them susceptible to human exploitation and how humans might have impacted these ecosystems Explain to students that when we study wetlands, it is difficult to avoid discussing human impact simultaneously. Students remain in groups for further discussion. What	Students explain how wetlands have very distinct ecosystem features and services and explain the economic services they provide as well. Students also explain how humans have impacted the environment and the consequences resulting from such impact. What can be done to alleviate the human impact on ecosystems?	45 mins

	characteristics of wetlands make them susceptible to exploitation? Elicit from students that climate change plays an important role in sea level rise. Humans have contributed to climate change and sea level rise (SLR) is a result of climate change. Wetlands are at risk of land subsidence and erosion as a result of SLR. A breathing planet off balance https://www.youtube.com/watch?time_continue=95&v=xk11DVaAjEA&feature=emb_logo NASA Climate Change. Carbon dioxide emissions from burning fossil fuels and earth's land and water absorb about half of all the carbon dioxide emissions. Climate change and sea level rise https://www.youtube.com/watch?v=cXzfOpZSmk8 https://climate.nasa.gov/climate_resources/144/video-how-global-warming-stacks-up/ https://climate.nasa.gov/vital-signs/sea-level/ NASA Climate Change. As human activity warms the planet, the oceans absorb more heat, this increases water volume and melts ice	HANDOUT: Why are wetlands essentials and what economic/ ecosystem services do they provide?	

	caps and glaciers, contributing to sea level rise. Wetlands are at risk as a result of sea level rise.		
Elaborate / Extend: **Allow students to use their new knowledge and continue to explore its implications.**	Elaborate on the study of Blue Carbon, a field that is gaining in popularity to be studied. Teacher provides the initial introductory resources for students to extend their understanding of wetlands to blue carbon storage. Teacher helps students activate prior knowledge about carbon cycle first: https://nasaeclips.arc.nasa.gov/video/launchp/real-world-the-carbon-cycle-essential-for-life-on-earth https://cdn.earthdata.nasa.gov/conduit/upload/5898/NASA_SOP_2016_where_the_wetlands_are.pdf *For enrichment, to connect students to the countdown to Mars (Artemis Mission), you can offer this assignment as enrichment: Next Gen STEM Resources: https://www.nasa.gov/stem/nextgenstem/index.html https://www.nasa.gov/stem/nextgenstem/moon_to_mars/mars2020stemtoolkit Connect astrobiology astrobiology questions about the	Students explore the importance of wetlands as it applies to the concept of Blue Carbon: https://www.iucn.org/resources/issues-briefs/blue-carbon https://www.thebluecarboninitiative.org/ https://carbon.nasa.gov/pdfs/CMSApplications_PolicySeries_slides_Oct.pdf	45 mins

	potential for life on Mars, using the grade 9-12 band. https://astrobiology.nasa.gov/education/alp/if-a-planet-can-have-life/ How did life on Earth come to occupy so many different environments? https://astrobiology.nasa.gov/education/alp/life-many-environments/ What types of conditions can life survive in? https://astrobiology.nasa.gov/education/alp/conditions-can-life-survive-in/ The Mars 2020 Perseverance Rover will search for signs of ancient microbial life, which will advance NASA's quest to explore the past habitability of Mars. The rover has a drill to collect core samples. https://mars.nasa.gov/mars2020/mission/overview/		
Evaluate: **Both students and teachers to determine how much learning and understanding has taken place.**	Provide exit slip to determine if students can outline the major economic and ecosystem services that wetlands provide. Teacher provides resources so that students can complete the HW: Blue Carbon Handout	Outline the services that wetlands can provide as it applies to Blue Carbon. Complete the homework Blue Carbon Handout	15 mins

6. NGSS standards, State science standards and Common Core standards utilized in lesson.

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Common Core Standard: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

7. NASA System Engineering Behavior Model utilized in lesson

- https://www.nasa.gov/pdf/291039main_NASA_SE_Behavior_Study_Final_11122008.pdf

Communicates effectively through personal interaction, builds team cohesion, seeks information and uses the art of questioning, remains open minded and objective, and learns from success and failures.

8. Supporting Documents: (order according to sequence of lesson.)


Why are wetlands essential?

1


What are wetlands?

2


Why are wetlands important?


Types of Wetlands
Saltmarshes
Mangroves


Agriculture as a threat to wetlands

9


Invasive Species as a threat to wetlands

10


Case study of invasive species: phragmites

11


Pollution

12

5

6


Human Impact on Wetlands

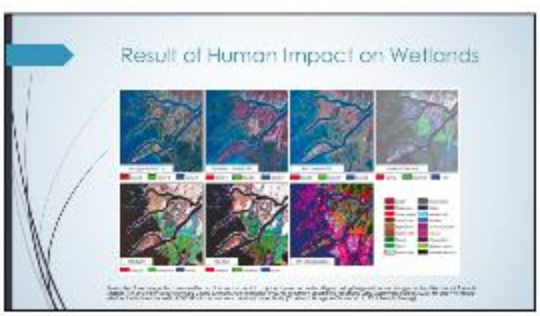

Industrial threats to wetlands


Climate change

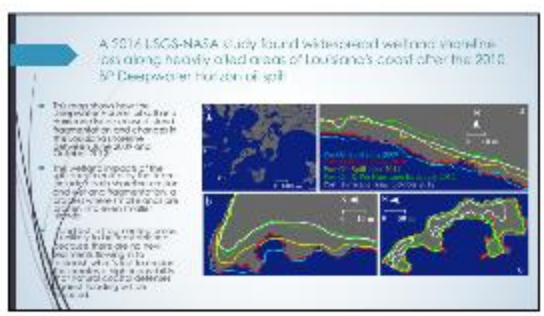
13


Dams and water diversion

14


Result of Human Impact on Wetlands

15


A 2016 USGS-NASA study found widespread wetland shoreline loss along heavily oiled areas of Louisiana's coast after the 2010 BP Deepwater Horizon oil spill

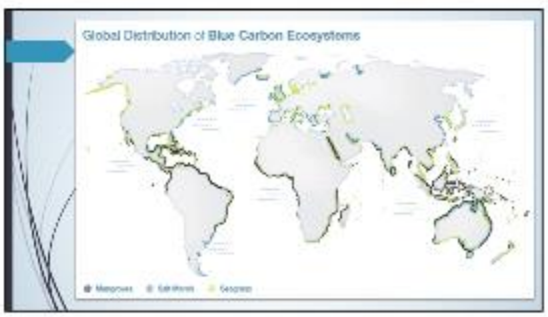
16

17

18

19

20



21

22

Why are wetlands essential in their ecosystem and economic service?
What is Blue Carbon?

In groups of three, discuss the characteristics of wetland ecosystems and how wetlands are susceptible to human exploitation. Further your discussion by including Blue Carbon and its significance in the carbon cycle. Then jot down your answers below.

1. General characteristics of wetlands (relative quantity of water, types of vegetation and animals, etc.)

____

____

2. Human impact on wetlands & resulting consequence

____

____

____

____

____

3. What is Blue Carbon? Why is it important?

____

____

____

____

____

Why are wetlands essential in their ecosystem and economic service?
EXIT SLIP

Briefly describe FOUR ecosystem and/or economic services that wetlands provide

1. ____

2. ____

3. ____

4. ____

What Is Blue Carbon?

Homework

Using the Blue Carbon Initiative website https://www.thebluecarboninitiative.org/and NASA's Carbon Monitoring System site (https://carbon.nasa.gov/index.html?) answer the following questions. Each question is worth 10 points. This background research will help you in your upcoming project.

1) What are blue carbon ecosystems? Name the ecosystems and explain their characteristics.

2) Why are coastal and marine ecosystems important for climate change mitigation?

3) Where are coastal blue carbon ecosystems found?

4) Compared to other ecosystems, do blue carbon ecosystems release significant amounts of carbon dioxide per unit area upon conversion or degradation?

5) What activities are causing the high rate of loss of coastal blue carbon ecosystems and how can such losses be reduced? Name at least two causes (5 points) and two ways in which such losses can be reduced (5 points).

Why are wetlands essential in their ecosystem and economic service? What is Blue Carbon? **ANSWER KEY (POSSIBLE ANSWERS)**

In groups of three, discuss the characteristics of wetland ecosystems and how wetlands are susceptible to human exploitation. Further your discussion by including Blue Carbon and its significance in the carbon cycle. Then jot down your answers below.

1. General characteristics of wetlands (relative quantity of water, types of vegetation and animals, etc.)

A wetland is an area of land that is either covered with water or saturated with water for significant periods of time. Unique plants, called hydrophytes, define wetland ecosystems. Wetlands have a great deal of biodiversity. We can find turtles, frogs, and a variety of birds.

2. Human impact & resulting consequence

    a. Dams and diversion of waters results in sediment accumulation behind the dam
    b. Drainage and development results in destruction of habitats and reduction of biodiversity
    c. Agricultural run-off results in increased nitrogen and dangerous algae blooms.
    d. Pesticide use, pollution results in habitat loss
    e. Clearing of wetlands results in flooding, decreased storm protection, release of stores carbon

Why are wetlands essential in their ecosystem and economic service?
EXIT SLIP
ANSWER KEY

Briefly describe FOUR ecosystem and/or economic services that wetlands provide

1. Provide coasts with storm protection
2. Provide habitats and promote biodiversity
3. Water filtration
4. Provide recreational space
5. Sequester/store carbon

What Is Blue Carbon?

Homework ANSWER KEY

Using the Blue Carbon Initiative website https://www.thebluecarboninitiative.org and NASA's Carbon Monitoring System site (https://carbon.nasa.gov/index.html?) answer the following questions. Each question is worth 10 points. This background research will help you in your upcoming project.

1) What are blue carbon ecosystems? Name the ecosystems and explain their characteristics.

   Tidal marshes, mangroves and seagrasses. Tidal marshes are wetlands with deep soils that are built through the accumulation of mineral sediment and organic materials and then flooded with salt water brought in by the rides. Mangroves are a type of tropical forest found at the edge of land and sea and flooded regularly by tidal water. Seagrasses are submerged flowering plants with deep roots.

2) Why are coastal and marine ecosystems important for climate change mitigation?
   The coastal ecosystems of mangroves, seagrass meadows and tidal marshes mitigate climate change by storing or sequestering carbon dioxide (CO2) from the atmosphere and oceans. They store carbon at significantly higher rates, per unit area, than terrestrial forests

3) Where are coastal blue carbon ecosystems found?

   Coastal blue carbon ecosystems can be found along the coasts of every continent except Antarctica.

4) Compared to other ecosystems, do blue carbon ecosystems release significant amounts of carbon dioxide per unit area upon conversion or degradation?
   When coastal ecosystems are degraded, lost or converted to other land uses, the large stores of blue carbon in the soils are exposed and released as CO2 into the atmosphere and/or ocean. Current rates of loss of these ecosystems may result in 0.15–1.02 billion tons of CO2released annually. Although the combined global area of mangroves, tidal marshes, and seagrass meadows equates to only 2–6% of the total area of tropical forest, degradation these systems account for 3–19% of carbon emissions from global deforestation. (https://www.thebluecarboninitiative.org/)

5) What activities are causing the high rate of loss of coastal blue carbon ecosystems and how can such losses be reduced? Name at least two causes (5 points) and two ways in which such losses can be reduced (5 points)

The activities causing the high rates of loss of the coastal blue carbon ecosystems are for the large part a result of human activities. Common causes are agriculture, land conversion and development, mangrove forest exploitation, terrestrial and marine sources of pollution, industrial and urban coastal development. We can reduce these losses by implementing policies, coastal management strategies, and the conserving and restoring of coast ecosystems.

Discussion Prompts

- Students view images of wetlands and discuss what they all have in common to come to a consensus to define/describe exactly what a wetland is
- Students discuss the economic and ecological services that wetlands provide, and relate them to Blue Carbon
- Students are asked to hypothesize what threats might exist to wetlands.
- Students discuss what can be done to decrease human impact.

Discussion Prompts—Suggested/possible answers

- Students view images of wetlands and discuss what they all have in common to come to a consensus to define/describe exactly what a wetland is
  - Wetlands are inundated with water throughout the year
- Students discuss the economic and ecological services that wetlands provide, and relate them to Blue Carbon
  - Wetlands sequester carbon, provide nesting areas for birds, provide biodiversity, filter water, are areas for tourism
- Students are asked to hypothesize what threats might exist to wetlands.
  - Development and destruction of wetlands, increase in agriculture and runoff, climate change, flooding, pollution, tourisms
- Students discuss what can be done to decrease human impact.
  - Wetland conservation and education, reuse and recycling programs, wetland restoration projects

Differentiated instruction activities

- Students work in heterogeneous groups and are grouped by reading and writing skill levels
- Presentation of information is multimodal and heavily supplemented with illustrations
- Students are asked a range of questions, representing lower and higher-level questions (What, why, how?)
- Students will use technology/websites in a highly interactive activity as an introduction to Blue Carbon

9. Conclusion and overview of linkages to next lesson and unit goals.

Students now see firsthand the ecological services that saltmarshes provide through their biodiversity, water filtration abilities, and ability to sequester carbon. This then leads into the next lesson where students explore the emerging concept of Blue Carbon.

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative Applied Research STEM Curriculum Portfolio

CCRI Unit Plan Template

NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

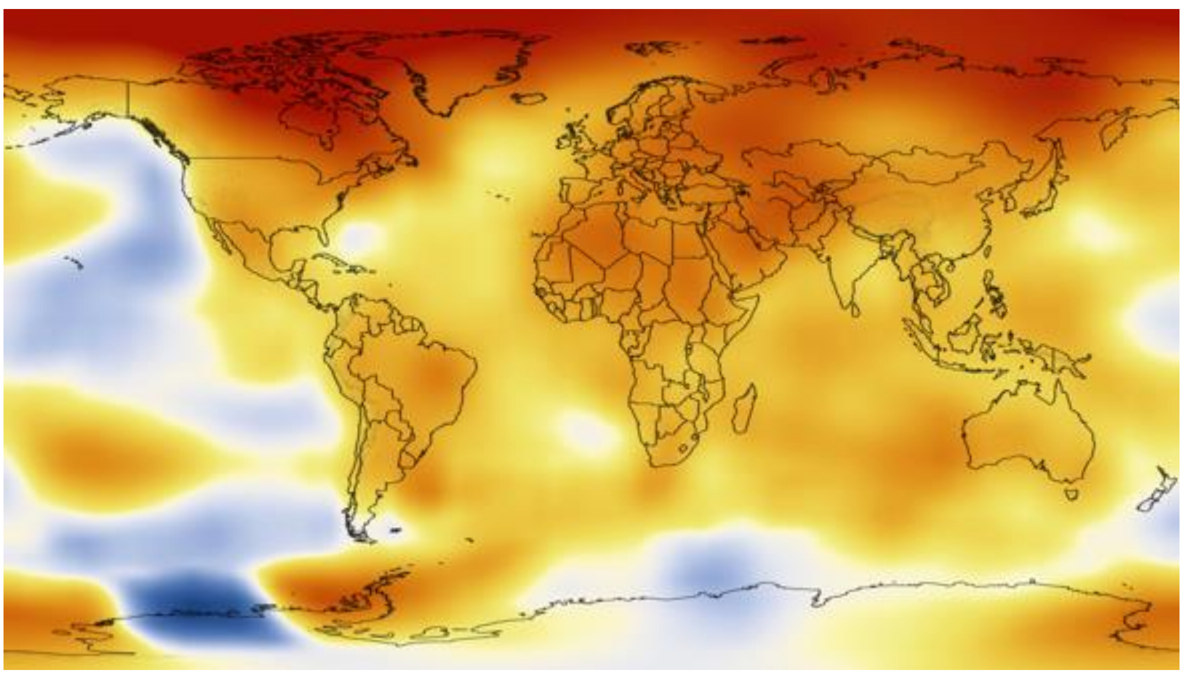
Unit Title: Blue Carbon

Bringing Field Research and ArcGIS Mapping to the High School Classroom

Lesson 2: *Blue Carbon: NASA Carbon Monitoring System*

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



XIII. Lesson 2: NASA Carbon Monitoring System

1. Table of Contents for lesson

2. Summary and Goals of Lesson

The goal of this lesson is to not only introduce students to the NASA Carbon Monitoring System website, but also for students to conduct a literature and data review of one specific topic as it pertains to Blue Carbon. Using the given NASA resources, students must be able to represent what they believe to be the most essential information to demonstrate what they want to present. Students will represent this as a poster, highlighting data tables and graphs or satellite imagery. Students will then peer review each other's posters, providing constructive criticism in presentation, content, and also student understanding and ability to present that to their peers.

Students will understand that the study of blue carbon is gaining in popularity and that the carbon estimated to be stored in coastal wetlands and in the soil have been historically underestimated. They will also understand that as humans disrupt the wetlands and coastal ecosystems, the impact is much more detrimental than previously thought.

3. CCRI Lesson Plan Content Template

NGSS Standards & NYS Standards: HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on State Science Content Standard: LE 5.1, 6.1, 6.2, 6.3, 7.1, 7.2 **Phenomenon:** Cycling of carbon **Crosscutting concepts:** Patterns Cause and Effect Systems and System Models Stability & Change	Common Core Standard: RST.11.12; HSS.IC.A.2 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	NASA Science: Earth Science

Content Area: Environmental Science Grade Level:11 & 12 grade	Name of Project-Based Activity or Theme: Data and literature review of current research of wetlands, sea level changes, climate changes. Students will then present their findings in a Scientific Poster (using PowerPoint or create an Infographic).	Estimated Time Frame to Complete(days/weeks): 7 days	

Overall Investigation Question(s): How can we read, analyze and present current research on wetlands and human impact, including sea level change and climate change.
Overall Project Description/Activity: Visit Alley Pond Park, a saltmarsh and survey flora and fauna that are native to the saltmarsh.

	:			
Materials Needed to Complete Project (put N/A as needed).	Stakeholders: Students, teacher, administrator, Alley Pond personnel	Hyperlinks Used: www.GlobalChange.Gov https://climate.nasa.gov https://cce.nasa.gov/cce/index.htm carbon.nasa.gov	Multimedia/Technology: Laptops with PowerPoint	Classroom Equipment: Laptops

Selected scientific articles (selected by teacher) Laptops for PowerPoint presentation		https://cce.nasa.gov/biodiversity/about.html https://www.carboncyclescience.us/ https://nasaeclips.arc.nasa.gov/video/realworld/real-world-the-carbon-cycle-essential-for-life-on-earth		
Analysis of research articles as a team and presentation of literature to the class, making use f=of the illustrations and being able to explain the articles, including methods and results			Smartboard, computer	smartboard
NASA System Engineering Behaviors (2 behaviors per category)	Category (must have one Technical Acumen)	Activities How will student model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes How will you assess learning for each behavior	Evaluation Describe specific science content students understand as a result of engineering behavior.
Uses visuals to communicate complex interaction	Communications	Students will have to present complex primary literature in an understandable form to their peers and explain data and imaging.	Works cooperatively with team mates to present literature in an understandable form	
Communicates effectively through personal interaction	Communications	Students will need to work in teams to dissect their article and then present it. Students need to come to a consensus on what is appropriate to include and how to present the materials	Completes the Poster or Infographic/Data & literature review assignment successfully with group members	
Builds Team Cohesion	Leadership	Students must work together and be able to delegate responsibilities and rely on each other to complete tasks	The presentation demonstrates equal division of work and participation	
Appreciates/Recognizes Others	Leadership	The team aspect of the activity helps students recognize others and the information they offer	The students will be able to handle the Q&A sessions with their peers, each person being an active participant. Perhaps each student will be an "expert" at particular points	
Has a comprehensive view	Attitudes & Attributes	While students will most likely divide up the work, each must have a comprehensive understanding of the assignment	The students will be able to handle the Q&A sessions with their peers, each person being an active participant.	
Seeks information and uses the art of questioning	Attitudes & Attributes	The students should be utilizing other resources, handouts and each other as information sources	Utilizes the resources given and also uses internet searches to help each other	
Validates facts, information and assumptions	Systems Thinking	In finding supporting articles and resources, students must validate information and distinguish between evidence-based statements and unsupported ones.	Is willing to adjust answers and identifications as new information rises	

Keeps the focus on mission requirements	Systems Thinking	Must focus on meeting deadlines and completion of project	Stays on task	
Learns from success and failures	Technical Acumen	Teacher will provide feedback as the project progresses and students must be willing and able to adjust.	Is willing to adjust answers	
List and attach all supportive documents for instructional activities	Attachments? Yes	Carbon Monitoring System samples posters and teach talking points What is Blue Carbon Handout Cornel Notes Organizer		
List and attach all rubrics for activity and assessment evaluation	Attachments? Yes	List Attached Rubrics (if any): Article review/summary rubric Presentation rubric What is Blue Carbon answer key		

4. Mission Alignment
This lesson plan is aligned to Terra, Landsat and ECOSTRESS.

5. Time to implement lesson: 3-4 days

6. Materials required

- Carbon Monitoring System (CMS) sample posters and talking points
- Student laptops
- Article summary rubric
- What is Blue Carbon handout and answer key
- NASA resources
    - www.GlobalChange.Gov
    - https://climate.nasa.gov
    - https://cce.nasa.gov/cce/index.htm
    - carbon.nasa.gov
    - https://cce.nasa.gov/biodiversity/about.html
    - https://www.carboncyclescience.us/
    - https://nasaeclips.arc.nasa.gov/video/realworld/real-world-the-carbon-cycle-essential-for-life-on-earth
-

7. 5 E lesson model template:

Lesson Title: What is Blue Carbon: A literature and data review
Grade Level: 11th and 12th grade
Duration: one week

	What the Teacher Does	**What the Students Do**	**Duration**
Engage: **Pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.**	Reviews the different sections of the NASA Carbon Monitoring System website, specifically the introductory page with the icons. Students should already be familiar with the site	Define the words/terms in the handout and provide background information to present to the class. Students will use the NASA's Carbon	30 minutes

	from doing the previous day's HW Teacher can provide a primer on Remote Sensing Fundamentals (https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing). Enrichment—teachers can have the students go through the training Group students and assign each group one of the terms to research and define. Students must then present their terms to the entire class. Students will use NASA's Carbon Monitoring System website as a resource carbon.nasa.gov/ Terms from the handout: i. Global Surface Temperature Flux ii. Ocean biomass iii. Land-Ocean Flux iv. Global Surface-Atmosphere Flux v. Land Atmosphere Flux vi. Land-Biomass vii. MRV/Decision Support	Monitoring System website as a resource. carbon.nasa.gov Enrichment—students can go through the training on Remote Sensing Fundamentals (https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing).	

Explore: **The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.**	Select models of a scientific poster from NASA's Carbon Monitoring System to demonstrate what kind of information is displayed and how much information the students can gather.	Review and annotate the poster, indicating what kind of information is provided, what data sets are shown, what conclusions can be drawn, as well as comments on overall layout.	20 minutes
Explain: **Provide students with an opportunity to communicate what they have learned so far and figure out what it means. EXPLAIN**	Students are instructed to discuss within their groups what information is provided on the poster. Teacher should elicit that because space is limited, the information on the poster should be selected carefully and words chosen strategically (no wasted space)	Students must be able to explain what makes a "good" poster or infographic in terms of information provided, in the use of words as well as graphics, graphs and data tables.	20 minutes
Elaborate / Extend: **allow students to use their new knowledge and continue to explore its implications.**	Instruct students that they are now going to create their own poster using various NASA resources www.GlobalChange.Gov https://climate.nasa.gov https://cce.nasa.gov/cce/index.htm carbon.nasa.gov/ https://cce.nasa.gov/biodiversity/about.html https://www.carboncyclescience.us/	Students will create and present their posters to the class and must be able to field questions. Students must be able to cite additional sources that helped them understand the articles Students must be able to relate the	2 hours

	Teacher provides guidance on creating a) a poster using PowerPoint or b) an Infographic [(https://www.jpl.nasa.gov/infographics/create.php)](https://www.jpl.nasa.gov/infographics/create.php)	article to our current topic.	
Evaluate: **Both students and teachers to determine how much learning and understanding has taken place.**	Teacher evaluates poster and presentation to the class, asks questions during presentation, and makes notes of student questions (rubric available) Teacher provides Cornell notes handout (http://lsc.cornell.edu/study-skills/cornell-note-taking-system/)	Students will conduct a peer evaluation of each other's poster and presentation. They must provide feedback to their peers and offer constructive criticism. (+/-) Students must note strengths and weaknesses and presentations. If time permits, students should have the opportunity to revise their posters based on feedback.	1 hour

8. NGSS standards, State science standards and Common Core standards utilized in lesson.

NGSS

HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on Earth

Common Core Standard: RST.11.12; HSS.IC.A.2
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

9. NASA System Engineering Behavior Model utilized in lesson

- https://www.nasa.gov/pdf/291039main_NASA_SE_Behavior_Study_Final_11122008.pdf

Uses visuals to communicate complex interaction, appreciates/recognizes others, has a comprehensive view, validates facts, information and assumptions, and keeps the focus on mission requirements.

10. Supporting Documents

WHAT IS BLUE CARBON?

Using the NASA resources listed below, you will conduct a literature and data review to explain Why is understanding blue carbon essential to understanding the role of our wetlands in the ecosystem services they provide?

A. Using carbon.nasa.gov

2) Definitions:
   a. click on each of the icons at the top and define:
      i. Global Surface Temperature Flux
      ii. Ocean biomass
      iii. Land-Ocean Flux
      iv. Global Surface-Atmosphere Flux
      v. Land Atmosphere Flux
      vi. Land-Biomass
      vii. MRV/Decision Support
         1. What does MRV stand for?

3) Look at the featured publications page
      i. Click on at least three examples of featured publications and the poster that accompanies it.
4) Using NASA's Carbon Monitoring System website, as well as the resources below, you will create your own poster (which is a one slide Power Point presentation) or infographic (https://www.jpl.nasa.gov/infographics/create.php). The goal of your poster is to guide you through talking points so that you can present the article and data that you have reviewed.
5) You will speak in illustrations, graphs, charts and tables. You should have talking points ready. You must cover the following:
   a. What is Blue Carbon?
   b. Why is it significant?
   c. Why have studies been limited?
   d. What studies have been done so far? Review one piece of literature or dataset that you can use to support your argument.
      i. What are the implications for the future with the study?
      ii. What does it tell us?

6) Responsibility of the audience:
   a. For each presentation, the class must take Cornell notes. There will be a time for Q&A and so you should be formulating questions for your peers. Students will grade and provide feedback to their peers.

NASA Resources:
https://cce.nasa.gov/biodiversity/about.html
https://www.carboncyclescience.us/

WHAT IS BLUE CARBON? ANSWER KEY

Using the NASA resources listed below, you will conduct a literature and data review to explain Why is understanding blue carbon essential to understanding the role of our wetlands in the ecosystem services they provide?

B. Using carbon.nasa.gov

7) Definitions:

a. click on each of the icons at the top and define:

i. Global Surface Temperature Flux

ii. Ocean-atmosphere flux
The exchange of carbon between the air and ocean is known as Ocean-Atmosphere flux. The oceans exchange a large amount of carbon with the atmosphere. CMS projects funded under this activity seek to better estimate the exchange of carbon between ocean and the air.

iii. Ocean biomass
Ocean biomass refers to the total mass of all living matter in the oceans. CMS scientists are focusing their efforts in researching concentrations of phytoplankton and distribution of calcifiers in oceans and lakes, which play an important role in controlling how much carbon is exchanged between the oceans and atmosphere.

iv. Land-Ocean Flux
Land-ocean flux refers to the exchange of carbon between the land and coastal waters. In order to understand the dynamics that control the movement of carbon from land to ocean, CMS scientists are using land-based and ocean-based models together to model terrestrial watershed processes in combination with coastal oceanic processes.

v. Global Surface-Atmosphere Flux
Global surface atmosphere flux refers to the total amount of carbon being moved annually between the land and ocean surface and the atmosphere.

vi. Land Atmosphere Flux
The exchange of carbon between the land and the air is referred to as Land-Atmosphere flux. CMS scientists are collecting better estimates of land biomass to use in models which predict how much carbon is released through biomass burning and deforestation

vii. Land-Biomass
Land Biomass is the total mass of all living matter on land, including all above ground grasses, trees, and shrubs. When biomass is removed through deforestation or burning, the carbon stored in the plants is released into the atmosphere. CMS scientists are improving current methods for measuring how much land biomass exists and its role in the carbon cycle.

viii. MRV/Decision Support

1. What does MRV stand for? Measurement, Reporting and Verification. Many Carbon Monitoring Systems (CMS) projects and data products are being designed for MRV Programs at a local, regional, national, and international scale, as well as to provide timely and useful information to decision makers.

8) Look at the featured publications page
    i. Click on at least three examples of featured publications and the poster that accompanies it.
9) Using NASA's Carbon Monitoring System website, as well as the resources below, you will create your own poster (which is a one slide Power Point presentation). The goal of your poster is to guide you through talking points so that you can present the article and data that you have reviewed.
10) You will speak in illustrations, graphs, charts and tables. You should have talking points ready. You must cover the following:
    a. What is Blue Carbon?
    b. Why is it significant?
    c. Why have studies been limited?
    d. What studies have been done so far? Review one piece of literature or dataset that you can use to support your argument.
        i. What are the implications for the future with the study?
        ii. What does it tell us?

11) Responsibility of the audience:
    a. For each presentation, the class must take Cornell notes. There will be a time for Q&A and so you should be formulating questions for your peers. Students will grade and provide feedback to their peers.

NASA Resources:

https://cce.nasa.gov/biodiversity/about.html
https://www.carboncyclescience.us/

Name______________________ Class_______________

Cornell Notes Organizer

<table>
<tr><td colspan="2">Section 1 (write today's aim here):
<u>Topic</u>: Blue Caron: Literature and Data Review
<u>Aim</u>: How does a review of the scientific literature and data expand our knowledge on Blue Carbon?</td></tr>
<tr><td colspan="2">Presentation:
Group members:
Name of Presentation:</td></tr>
<tr><td colspan="2">Academic Vocabulary (list and define):
1.
2.
3.
4.
5.</td></tr>
<tr><td>Section 3: Use this section to list main ideas, write questions, jot down additional vocabulary. You can draw conclusions and make predictions in this section.</td><td>Section 2: Use this section to take notes on the discussion or presentation that are relevant to the aim at the top of this page. (You can indicate strengths (+) and areas for improvement (-) in either section 2 or 3)</td></tr>
<tr><td colspan="2">Section 4: Use your notes to answer the aim in 3-4 sentences here. Cite specific evidence from the presentation or discussion to support your ideas. You must use academic vocabulary in your answer.</td></tr>
</table>

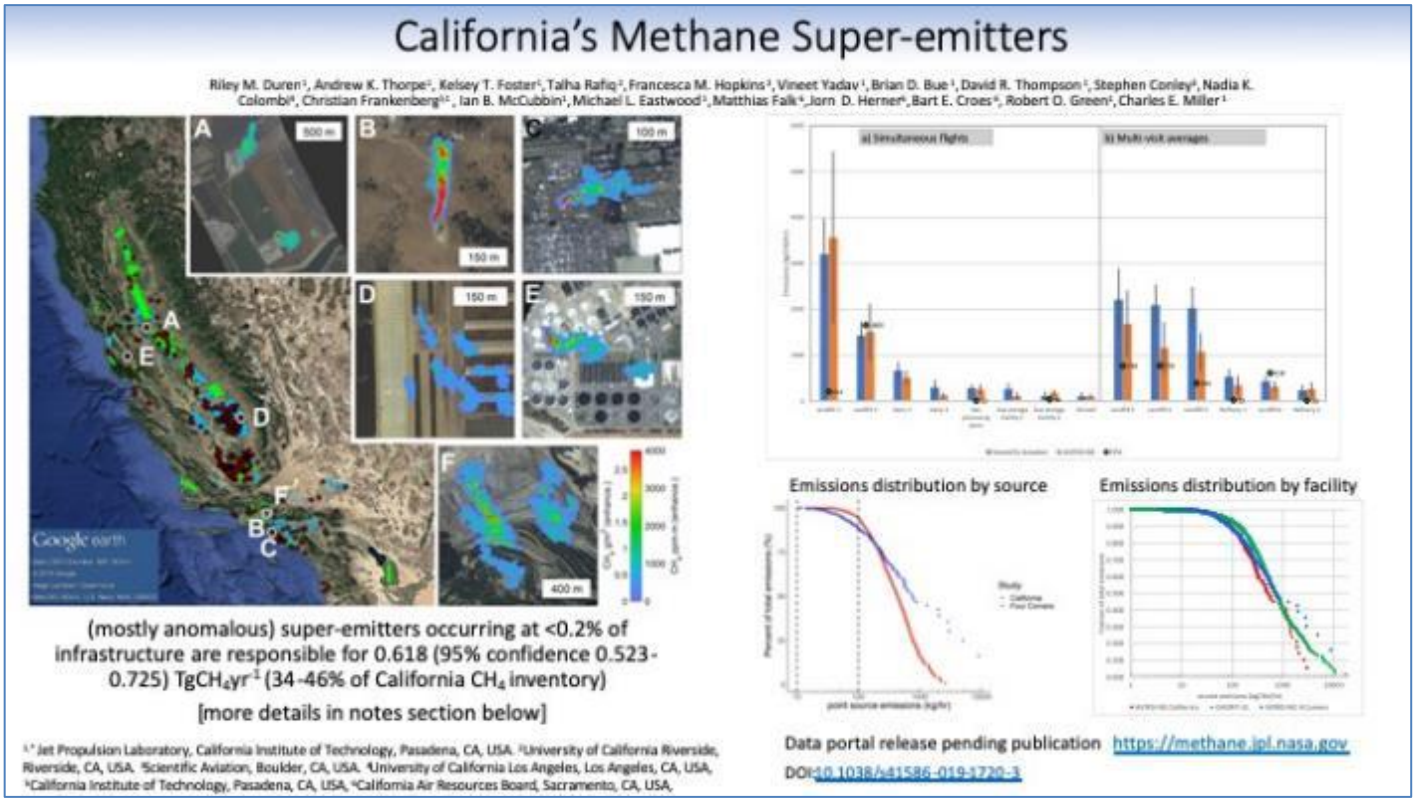
Blue Carbon Poster/Infographic Project Rubric

Criteria	Exceeds Standards (4)	Meets Standards (3)	Approaching Standards (2)	Below Standards (1)
1. Background information	The background information progresses in a logical way that provides substantial context.	The background information provide context.	The background information does not provide context or is unrelated.	There is no background information provided
Claim: Why is Blue Carbon significant?	The claim demonstrates a deep understanding of the science topic	The claim demonstrates an understanding of the science topic	The claim is inaccurate or implausible	No claim is provided
2. Evidence	All evidence used to support the claim is accurate, sufficient, appropriate, and well represented.	Most evidence used to support the claim is accurate, sufficient and appropriate.	Some evidence used to support the claim is accurate, sufficient and appropriate.	No evidence is given
3. Reasoning	Thoroughly relates evidence to scientific principles in order to support the claim. Reasoning is logical, accurate and complete.	Somewhat relates evidence to scientific principles in order to support the claim. Reasoning is mostly logical, accurate and complete.	Reasoning is illogical and incomplete or inaccurate.	No reasoning is given.
4. Writing Quality & Clarity	Writing uses clear, concise and expressive language. Writing accurately includes scientific terms and vocabulary.	Writing uses clear and understandable language. Writing accurately includes scientific terms and vocabulary.	Writing uses clear and understandable language. Writing uses conventional terminology and vocabulary.	Writing does not use clear and understandable language. Writing uses conventional terminology and vocabulary.
5. Proofreading & editorial aspects	Writing is grammatically accurate and error free	Writing is grammatically accurate with some typos.	Writing has some grammatical errors and typos.	Writing has not been proofread.
6. Quality use of visuals	Graphs, tables and visuals are meaningful and selected to heighten the quality of the work.	Graphs, tables and visuals are mostly meaningful or have ancillary significance.	Visuals are not completely related to the work and/or do not add to the work.	No visuals, graphs, or tables are used
7. Organization	The content is well organized and the layout is logical and makes use of the space.	The content is organized and the layout is logical.	The layout is somewhat organized.	The layout is disorganized and does not make good use of the space.
8. Content: Literature	Presenter demonstrates a deep understanding of the content of the literature/data reviewed	Presenter demonstrates and understanding of the content of the literature/data reviewed	Presenter ha a cursory understanding of the literature/data reviewed	Presenter does not understand the content.
9. Inclusion of a variety of resources	A variety of different resources are used (4-5)	Different resources are used (2-3)	Some resources are used (1-2)	No other resources are used
10. Oral presentation skills	Presenter spoke loudly and clearly, was well paced, made eye contact. Delivery is smooth and poised during the entire duration.	Presenter spoke clearly and loudly most of the time.	Speaker was audible and clear some of the time.	Presenter did not speak clearly or loudly enough, did not make eye contact.

Blue Carbon Poster/Infographic Project Rubric

11. Enthusiasm and effort	Presenter was animated and enthusiastic while presenting.	Presenter was enthusiastic during the presentation.	Presenter showed some enthusiasm.	Presenter did not show any enthusiasm

An example of a CMS poster:



Notes section:

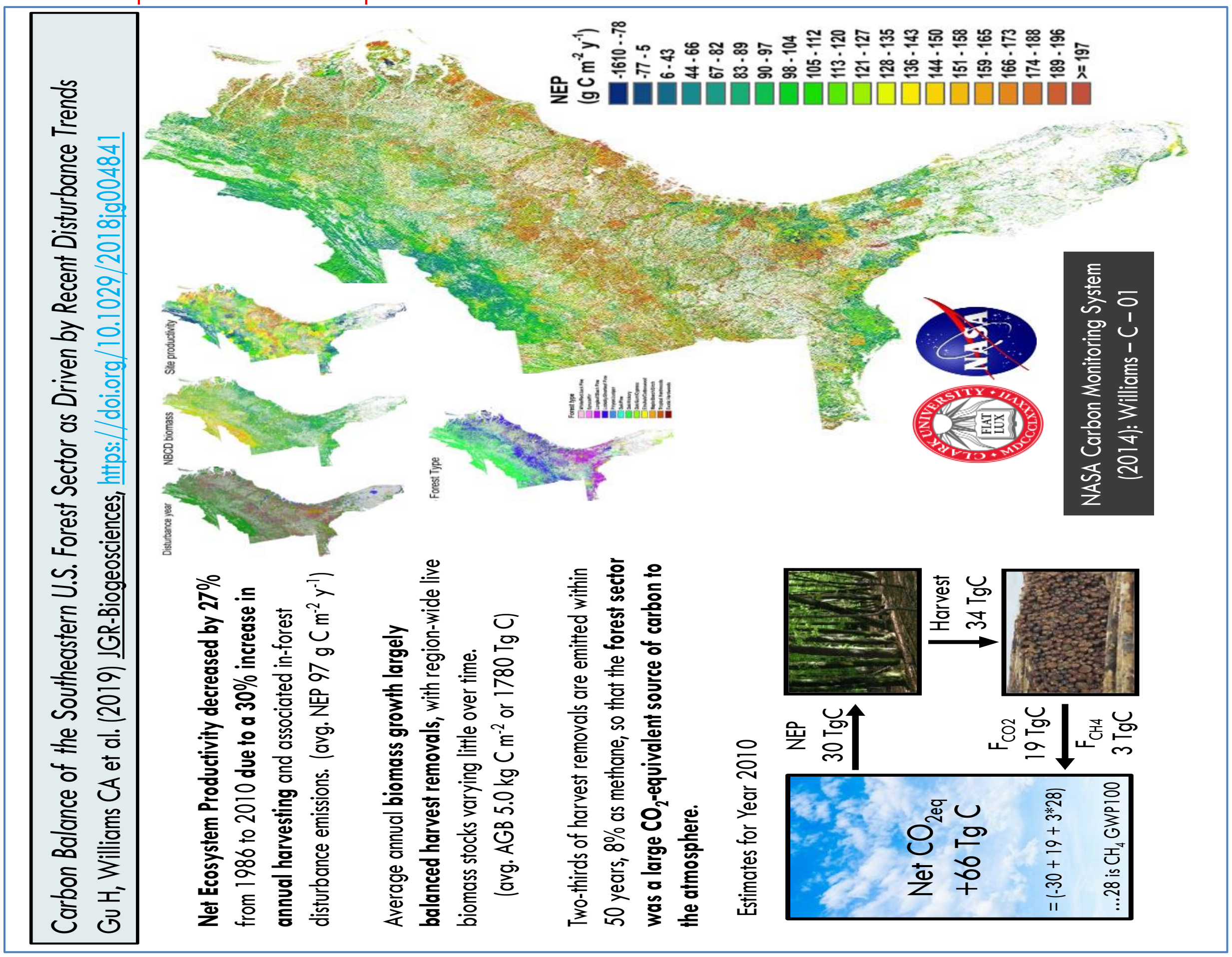
Point source emissions (surface features or infrastructure components typically less than 10 m diameter that are emitting plumes of highly concentrated methane) present unique opportunities for mitigation. Existing data are sparse and typically lack sufficient spatial and temporal resolution to guide mitigation and accurately assess the magnitude of point source emissions. Here we survey over 272,000 infrastructure elements in California with NASA's next generation Airborne Visible/Infrared Imaging Spectrometer (AVIRIS-NG). We conducted five campaigns over several months from 2016 to 2018, spanning the oil and gas, manure management, and waste management sectors resulting in the detection, geolocation, and quantification of 564 strong methane point sources. Funded by the California Air Resources Board, California Energy Commission and NASA. The plane typically flew at altitudes of 3km with 1.8km wide swath. AVIRIS-NG operates in the visible to SWIR and is able to detect and quantify CH4 in the 2300 nm band. This approach enables rapid and repeated assessment of large areas at high spatial resolution for a poorly characterized population of methane emitters that often appear intermittently and stochastically. Methane super-emitter activity occurs in every surveyed sector; with 10% of point sources contributing ~60% of point source emissions – consistent with a study of the Four Corners region that has a different sectoral mix. The largest methane emitters in California are landfills exhibiting persistent anomalous activity. We find that methane point source emissions in California are dominated by landfills (41%) followed by dairies (26%) and the oil and gas sector (26%). About 80% of oil and gas point source emissions are attributed to upstream production. We observed a 4.5% production-normalized CH4 emission rate from oil fields in the San Joaquin Valley – consistent with models. Our data allows for the identification of the 0.2% of California's infrastructure responsible for those emissions and sharing our data with collaborating infrastructure operators has led to the mitigation of anomalous methane emission activity (one major landfill and 5 hazardous natural gas leaks). Broader application of these methods to key methane emitting regions globally by aircraft and satellites could yield more insight into the contribution of point sources to methane budgets and enable efficient mitigation.

Funded by NASA NASA Carbon Monitoring System Grant: NNN12AA01C

Teacher talking points:

- Heavily illustrated; use of graphs and illustrations
  Graphs and maps are properly labeled
- PPT notes section is used for speaker talking points
- Succinct and clear title on what the paper covers
- Citations and acknowledgements properly included

Example #2 of CMS poster



Teacher talking points:

- Heavily illustrated; use of graphs and illustrations
  Graphs and maps are properly labeled
- PPT notes section is used for speaker talking points
- Succinct and clear title on what the paper covers
- Citations and acknowledgements properly included
- Bulleted talking points on the side panel
- Both presenter and audience can see what the article/research intends to cover.

Discussion Prompts

- Students are expected to take notes and develop their own questions for their peers during each presentation
- Questions will prompt discussion as it relates to Blue Carbon.

Differentiated instruction activities

- Students work in groups for this highly interactive activity
- Presentation of information is multimodal and heavily supplemented with illustrations
- Students are asked a range of questions, representing lower and higher-level questions (What, why, how?)
- Students are working at different speeds and at different levels as they research their topics and put it together in a presentation
- Students will be able to take on different roles within their groups and are encouraged to highlight their strengths

11. Conclusion and overview of linkages to next lesson and unit goals.

The lesson on Blue Carbon is the unifying theme for the unit. The purpose is for students to understand the significance of blue carbon and its role in ecosystems. They focus on actual literature and studies that have been completed and what the current data exists in the field. They then move onto the next lesson that examines the Urban Heat Island Effect and relate it to how plant ecosystems help to moderate the effect of urban buildings and materials.

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative

Applied Research STEM Curriculum Portfolio

CCRI Unit Plan Template

NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

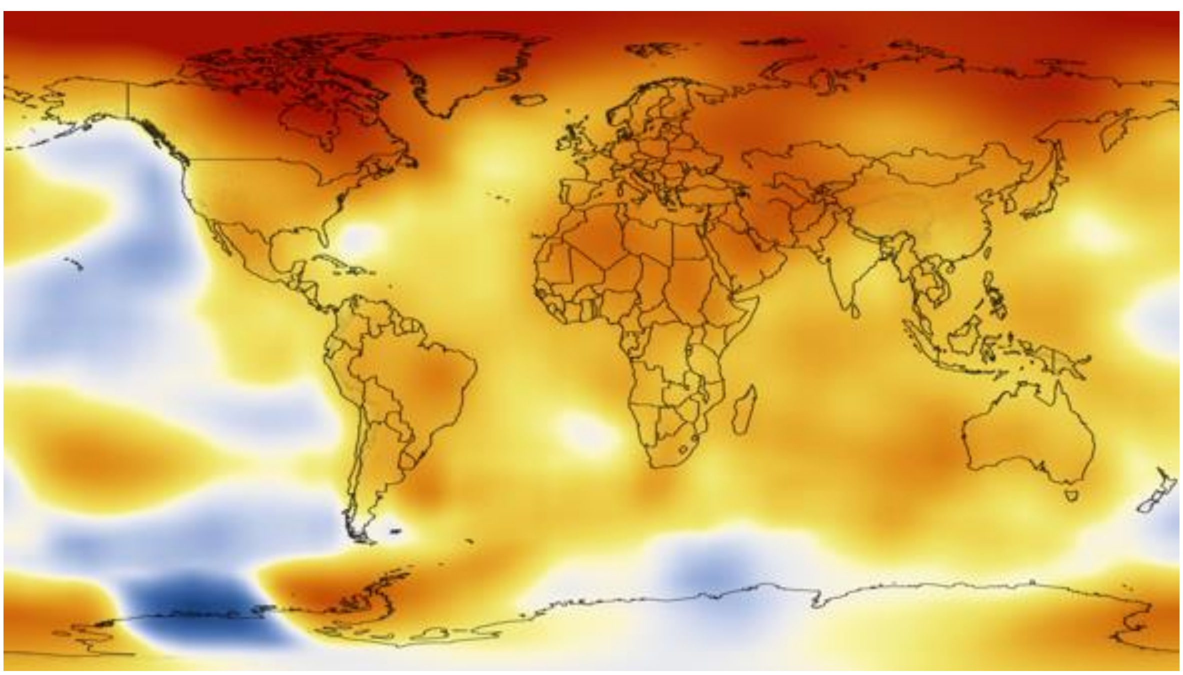
Unit Title: Blue Carbon

Bringing Field Research and ArcGIS Mapping to the High School Classroom

Lesson 3: *Urban Heat Island Effect*

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



XIV. Lesson 3: Urban Heat Island Effect

1. Table of Contents for lesson

2. Summary and Goals of Lesson

This lesson examines the Urban Heat Island Effect and relates it to how plant ecosystems help to moderate the effect of urban buildings and materials. Students will be introduced to NASA's ECOSTRESS maps that capture surface temperatures, comparing them among rural and urban areas. Students will also view NASA/USGS satellite Landsat images that show the cooling effects of plants on New York City's heat, thereby demonstrating the importance of vegetation.

3. CCRI Lesson Plan Content Template

NGSS Standard: HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity **Phenomenon:** Urban Heat Islands **Crosscutting concepts:** Patterns Cause and Effect Systems and System Models Stability & Change	Common Core Standard: RST.11.12; HSS.IC.A.2 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3) **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing	NASA Science: Earth Science

			on addressing what is most significant for a specific purpose and audience. (HS-LS2-3) **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)	
Content Area: Environmental Science/Science Research Grade Level: 11th and 12th grades	Name of Project-Based Activity or Theme: Urban Heat Island Effect			Estimated Time Frame to Complete Lesson: 2 days
Overall Investigation Question(s): How can we explain the Urban Heat Island Effect?				
Materials Needed to Complete Project : NASA video explaining Urban Heat Island	Stakeholders: Teachers students	Hyperlinks Used: https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects https://www.youtube.com/watch?v=s9tMC_80qRQ https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation https://lpdaac.usgs.gov/resources/data-action/ecostressed-measuring-temperatures-cities-during-extreme-heatwaves/ ArcGIS StoryMaps Mapping Urban Hotspots using NASA Earth Observations in New York City https://storymaps.arcgis.com/stories/a8f232ac363f499d88a64fb0f8b226a9 ECOSTRESS https://www.youtube.com/watch?v=jo9J76rNXcM NASA Science Casts: Sweating Can be Cool https://www.youtube.com/watch?v=1BYyV8e4vq8&t=1s	Multimedia/Technology: smartboard	Classroom Equipment: Laptops with internet connection

NASA System Engineering Behaviors: (1 behaviors per category)	Category (must have one Technical Acumen)	Activities: How will students model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes: How will you assess learning for each behavior	Evaluation: Describe specific science content students understand as a result of engineering behavior.
Ensures system integrity	Leadership	Students will create their own map and indicate where the heat sources would be.		The map that students create will indicate
Communicates effectively through personal interaction	Communications	Students need to work in groups to discuss the mapping of urban heat islands	Analysis of different maps and areas.	
Seeks information and uses the art of questioning	Attitudes & Attributes	Students use different images and imaging systems		
Validates facts, information and assumptions	Systems Thinking	Students utilize the background information grounded in primary research articles.	Students support their findings with science and fact.	Students cite primary literature and appropriate, reliable sources.
Learns from success and failures	Technical Acumen			
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes or	List Attached Documents (if any): Urban Heat PPT How to create a google earth map		
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? (circle) Yes or No	List Attached Rubrics (if any):		
Include comments or questions here:				

4. Mission Alignment

This lesson plan is aligned with the ECOSTRESS and Landsat missions.

5. Time to implement lesson: 2 days

6. Materials required

- NASA Resources:
  Hyperlinks Used:
  https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects

  https://www.youtube.com/watch?v=s9tMC_80qRQ

  https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation

  https://lpdaac.usgs.gov/resources/data-action/ecostressed-measuring-temperatures-cities-during-extreme-heatwaves/

  ArcGIS StoryMaps
  Mapping Urban Hotspots using NASA Earth Observations in New York City
  https://storymaps.arcgis.com/stories/a8f232ac363f499d88a64fb0f8b226a9

  ECOSTRESS
  https://www.youtube.com/watch?v=jo9J76rNXcM

  NASA Science Casts: Sweating Can be Cool
  https://www.youtube.com/watch?v=1BYyV8e4vq8&t=1s

- Urban Heat PPT
- How to create a google earth map PPT and handout & Answer Key
- Cornell Notes Organizer
- NYC ArcGIS Handout & Answer Key

7. 5 E lesson model template:

- https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e

Lesson Title: Urban Heat Island Effect
Grade Level: 11th and 12th grades
Duration: One day

	What the Teacher Does	What the Students Do	Duration
Engage: **Pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.**	The teacher provides a primer on the Urban Heat Island Effect and integrates the following resources: https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects The teacher begins with a general overview, possibly just showing the video to solicit answers from students. NASA | Urban Heat Islands https://www.youtube.com/watch?v=s9tMC_80qRQ The teacher then piques students interests by making it more relatable since this article discusses New York City specifically. (This website provides mapping of several cities to be used for comparison) https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation	Take notes and answer questions on the Cornell notes organizer worksheet.	20 mins
Explore: **The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.**	Background information: https://lpdaac.usgs.gov/resources/data-action/ecostressed-measuring-temperatures-cities-during-extreme-heatwaves/ Background information on ECOSTRESS is available for teachers: https://www.youtube.com/watch?v=7d1beGfOHPs Teachers shows students this background video on ECOSTRESS ECOSTRESS https://www.youtube.com/watch?v=jo9J76rNXcM NASA Science Casts: Sweating Can be Cool https://www.youtube.com/watch?v=1BYyV8e4vq8&t=1s	Students will now further explore the concept of urban heat to the importance of vegetation in mitigating rising temperatures via the ECOSTRESS videos and independent research.	30 mins

Explain: **Provide students with an opportunity to communicate what they have learned so far and figure out what it means.**	Direct students to share out their findings as a whole group.	Students will share out their findings/conclusions based on their videos and discussions as a whole group.	25 mins
Elaborate / Extend: **allow students to use their new knowledge and continue to explore its implications.**	Teacher introduces students to mapping systems so that they can map out an area of Alley Pond Saltmarsh or Jamaica Bay and guess what areas have higher surface temperatures. (PowerPoints available)	Students use Google Earth or Google Earth pro to map out an area of Alley Pond or Jamaica Bay that they would want to explore. They are to make predictions as to relative temperatures of the area and support their predictions with rationale.	60 min
Evaluate: **Both students and teachers to determine how much learning and understanding has taken place.**	Teacher introduces students to ArcGIS using ArcGis Story Maps: ArcGIS StoryMaps Mapping Urban Hotspots using NASA Earth Observations in New York City https://storymaps.arcgis.com/stories/a8f232ac363f499d88a64fb0f8b226a9 Teachers ask students to compare their predictions with the StoryMap in terms of finding the range of temperatures	Students continue to explore Urban Heat Islands as it applies to New York City specifically using ArcGIS StoryMaps. ArcGIS StoryMaps Mapping Urban Hotspots using NASA Earth Observations in New York City https://storymaps.arcgis.com/stories/a8f232ac363f499d88a64fb0f8b226a9 Compare the surface temperature findings to your predictions. Were you correct?	45 mins

8. NGSS standards, State science standards and Common Core standards utilized in lesson.

NGSS Standards:

HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Common Core Standard: RST.11.12; HSS.IC.A.2
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3)

9. NASA System Engineering Behavior Model utilized in lesson
    - https://www.nasa.gov/pdf/291039main_NASA_SE_Behavior_Study_Final_11122008.pdf

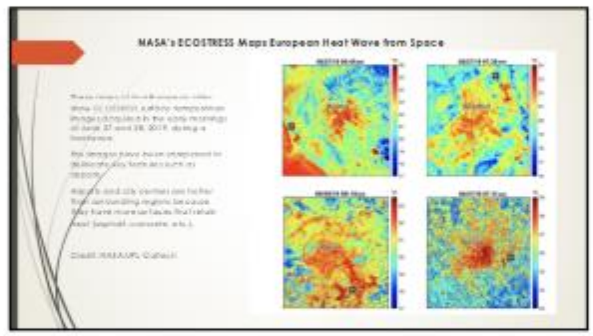
Ensures system integrity, communicates effectively through personal interaction, seeks information and uses the art of questioning, learns from success and failures.

10. Supporting documents

1

2

3



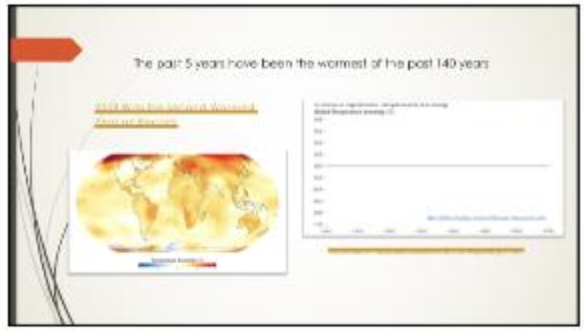
4

5

6


Satellite Data

7


The past 5 years have been the warmest of the past 140 years

8

NASA: Urban Heat Islands Name__________________

Cornell Notes Organizer

Section 1 (write today's aim here):

Topic: Urban Heat Island

Aim: How can we explain the Urban Heat Island?

Academic Vocabulary:

1.
2.
3.
4.
5.

Section 3: Use this section to list main ideas, write questions, jot down additional vocabulary. You can draw conclusions and make predictions in this section.	**Section 2**: Use this section to take notes on the discussion or presentation that are relevant to the aim at the top of this page.

.

Section 3: Answer the following questions:

1) What does urban heat island affect that drives worldwide interest?

2) What happens when we build an urban area? What happens to the temperature as a result?

3) What factors affects urban heat island?

4) What kind of data was collected to support their conclusions?

5) Why should urban heat islands matter?

Section 4: Use your notes to answer the aim in 3-4 sentences here. Cite specific evidence from the presentation or discussion to support your ideas. You must use academic vocabulary in your answer	**Section 5: HW** HW: This video features NASA satellite imagery. https://www.youtube.com/watch?v=Od2d1bYQVHs 1) What does land surface temperature vary with? 2) Where are some notable heat islands? 3) How can we combat the heat island effect?

NASA: Urban Heat Islands Name__________________
ANSWER KEY

Cornell Notes Organizer

Section 1 (write today's aim here):

Topic: Urban Heat Island

Aim: How can we explain the Urban Heat Island?

Academic Vocabulary: (answers may vary)

1. Urban Heat Island
2. Impervious
3. Albedo
4. Land surface temperature
5. Satellite data

Section 3: Use this section to list main ideas, write questions, jot down additional vocabulary. You can draw conclusions and make predictions in this section.	**Section 2**: Use this section to take notes on the discussion or presentation that are relevant to the aim at the top of this page.

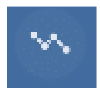
.

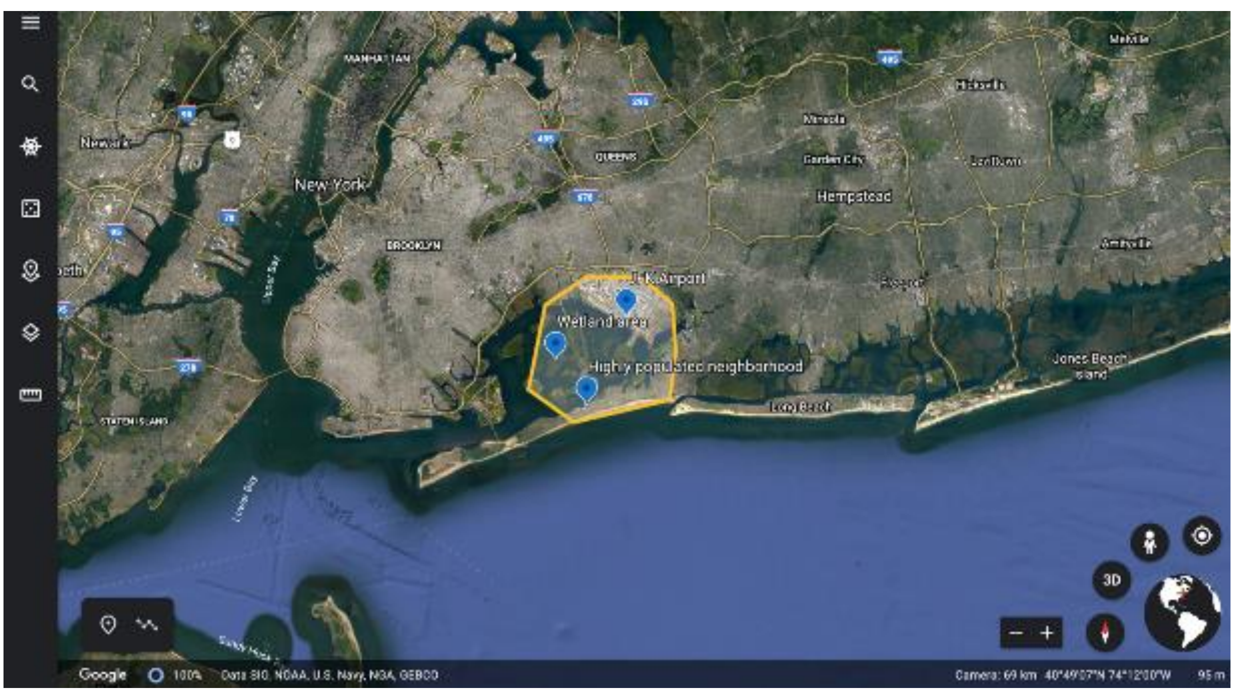
Section 3: Answer the following questions:

1) What does urban heat island affect that drives worldwide interest?
   Urban heat island affect human health and it affects energy consumption
2) What happens when we build an urban area? What happens to the temperature as a result?
   Replacing the vegetative and soil surface with impervious surfaces like paving and building materials. Warming the urban areas
3) What factors affects urban heat island?

The surrounding ecological context and the size of the city, bit the area of the city and the population size, and the shape of the city 4) What kind of data was collected to support their conclusions? Land surface temperature from MODIS 5) Why should urban heat islands matter? Health, like asthma and heart conditions, how much heating and cooling you need to use	
Section 4: Use your notes to answer the aim in 3-4 sentences here. Cite specific evidence from the presentation or discussion to support your ideas. You must use academic vocabulary in your answer	**Section 5: HW** HW: This video features NASA satellite imagery. https://www.youtube.com/watch?v=Od2d1bYQVHs 1) What does land surface temperature vary with? Wind, land surface, season, albedo 2) Where are some notable heat islands? Manhattan, London 3) How can we combat the heat island effect? Reflective surfaces, vegetated roofs, planting urban trees, more pervious surfaces

Mapping in Google Earth
Predicting Urban hot spots

1) Go to https://earth.google.com/web/
2) Click the search icon 
3) Enter Alley Pond Environmental Center or Jamaica Bay Wildlife Refuge
4) Click on the icon for new projects
5) Title your Untitled Project with the name of the wetland. 
6) Provide a description to your project (include the words Urban Heat and Mapping)
7) Outline your sample area. 
8) Add measurements of distance and calculate area 
9) Add placemarks to different areas. Remember what affects surface temperature and how and make sure to make note of this in the information section. 
10) You must select at least 5 areas of what you think will vary in temperature and you must explain why you think they will vary in temperature.

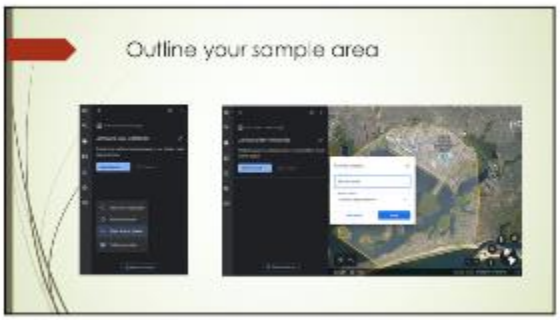



Mapping in Google Earth
Creating a new project

1


Give the project a description

2


Outline your sample area

3


Adding placemarks

4


Example:
JFK Airport

5


Example:
Wetland area

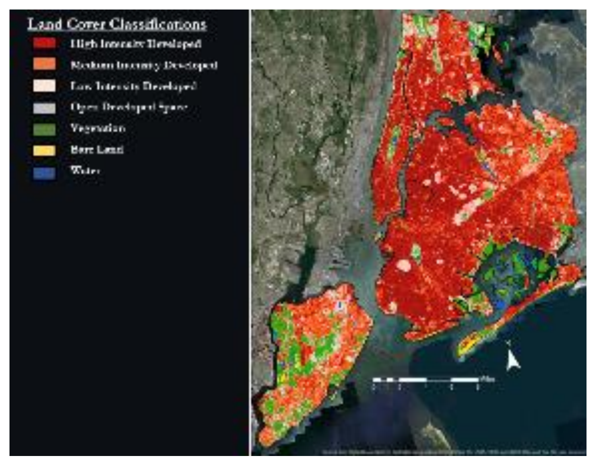
6


Example:
Urban Neighborhood

7

1) What causes urban thermal hotspots?

2) How can we combat thermal hotspots?
Hint—review the map of land use.



3) What does this tell you about the importance of wetlands?

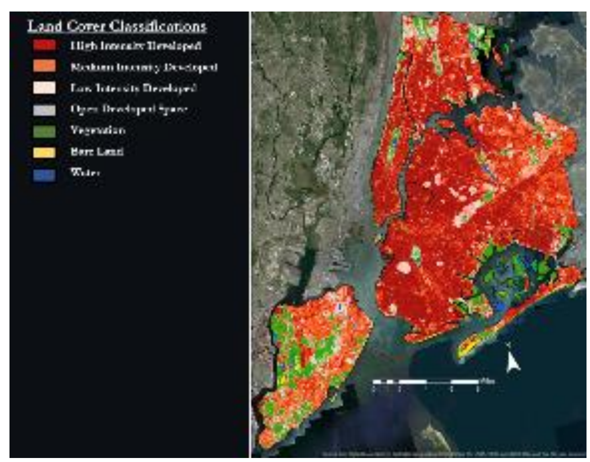
Teacher Answer Key

1) What causes urban thermal hotspots?

Thermal hotspots are a result of the larger Urban Heat Island Effect. It can be caused by a large amount of impervious surfaces, such as concrete, metal and asphalt, that absorb solar radiation.

2) How can we combat thermal hotspots? Hint—review the map of land use.

We can combat thermal hotspots by increasing vegetation (planting more trees, bushes and additional green space). The more developed an area, the higher the temperature.



3) What does this tell you about the importance of wetlands?
Wetlands help mitigate the temperature of surrounding areas. By providing shade and greenspace, it helps to keep temperatures from being too high.

Discussion Prompts

1) What does urban heat island affect that drives worldwide interest?
2) What happens when we build an urban area? What happens to the temperature as a result?
3) What factors affects urban heat island?
4) What kind of data was collected to support their conclusions?
5) Why should urban heat islands matter?
6) How does land use affect urban hotspots?

Suggested answers to discussion prompts:

1) What does urban heat island affect that drives worldwide interest?
   Urban heat island affect human health and it affects energy consumption
2) What happens when we build an urban area? What happens to the temperature as a result?
   Replacing the vegetative and soil surface with impervious surfaces like paving and building materials. Warming the urban areas
3) What factors affects urban heat island?
   The surrounding ecological context and the size of the city, bit the area of the city and the population size, and the shape of the city
4) What kind of data was collected to support their conclusions?
   Land surface temperature from MODIS
5) Why should urban heat islands matter?
   Health, like asthma and heart conditions, how much heating and cooling you need to use
6) How does land use affect urban hotspots?
   Vegetation decreases surface temperature, thereby supporting the fact that we must save wetlands and green areas.

Differentiated instruction activities

Delivery of instruction is multimodal in that the video allows for visual supports and the discussion portion for peer to peer interaction. Students use their notes organizer to formulate questions and to note vocabulary. For lower level students, the teacher can provide the vocabulary words and hints.

11. Conclusion and overview of linkages to next lesson and unit goals.

This lesson is intended to cover how urban heat islands are a result of urbanization—essentially the increase in impervious building materials such as concrete and asphalt, while plant matter and soil decreases. This emphasizes the importance of wetlands and plant ecosystems and the services they provide in moderating temperatures. At this point, introducing Google Earth to begin mapping and ArcGIS in its Story Maps helps students to begin visualizing and using computational math. This lesson leads into the lesson on land surface temperature and engages the students to hypothesize what areas on their school campus can contribute to hot spots.

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative

Applied Research STEM Curriculum Portfolio

CCRI Unit Plan Template

NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

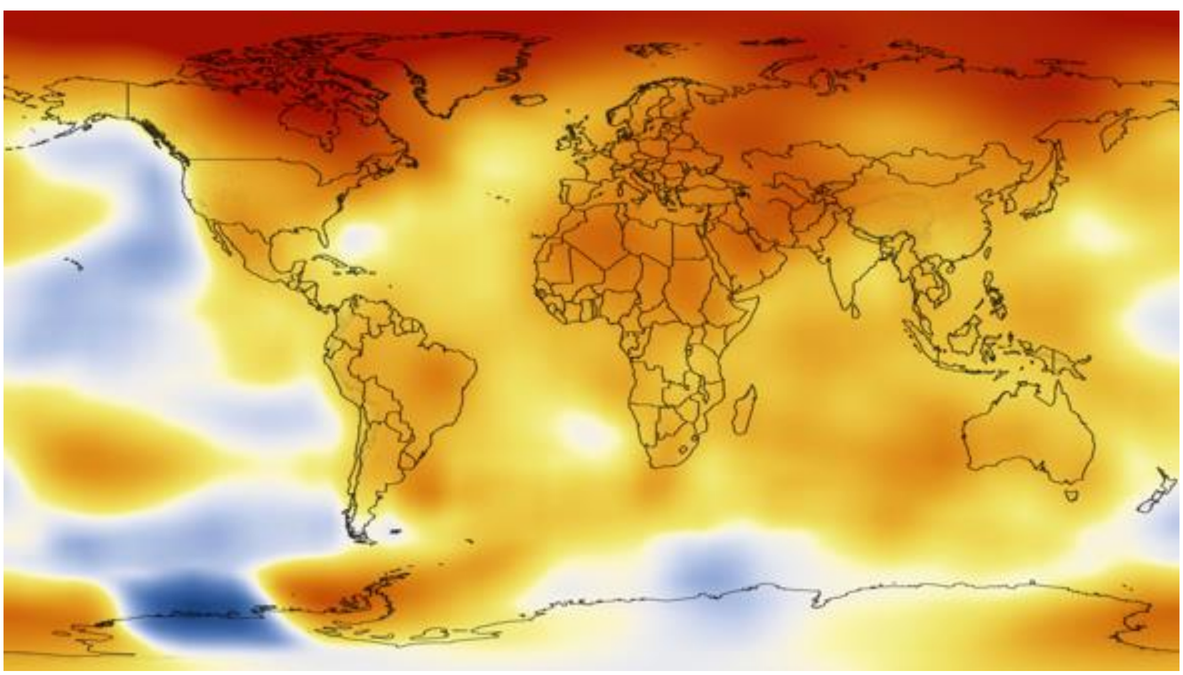
Unit Title: Blue Carbon

Bringing Field Research and ArcGIS Mapping to the High School Classroom

Lesson 4: *Land Surface Temperature*

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



XV. Lesson 4: Land Surface Temperature

1. Table of Contents for lesson

2. Summary and Goals of Lesson

Students will learn what affects land surface temperatures and using the information they learned from the previous lesson will be able to select different areas on the school campus that will results in varying surface temperatures. Students will perform field work and use handheld infrared temperature guns to measure and record different surface temperatures. Students will also upload their data to GLOBE.

3. CCRI Lesson Plan Content Template

NGSS Standards and NYS Science Standards HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on **Phenomenon:** Urban Heat Islands **Crosscutting concepts:** Patterns Cause and Effect Systems & System Models Stability and Change	**Common Core Standard**: RST.11.12; HSS.IC.A.2 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	**NASA Science:** Earth Science

Content Area: Environmental Science or Science Research Grade Level:11 & 12 grade	Name of Project-Based Activity or Theme: Measuring Surface Temperature		Estimated Time Frame to Complete(days/weeks): 3 days	
Overall Investigation Question(s): How can we investigate the Urban Heat Island Effect by measuring surface temperatures?				
Overall Project Description/Activity: Selection and mapping of sample areas to take surface temperature readings, following GLOBE Protocols.				
	:			
Materials Needed to Complete Project (put N/A as needed). Infrared Thermometer (IRT) Measuring tape or meter stick Google Maps Pen/pencil, paper	Stakeholders Students, teacher, administrator,	Hyperlinks Used: Surface Temperature Training: https://www.globe.gov/web/surface-temperature-field-campaign Surface Temperature Protocol https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5 Teacher Guide: https://www.globe.gov/documents/2981444/3462601/STFC-TeacherParticipationGuide.pdf Surface Temperature Data Sheet:	Multimedia/Technology Smartboard, computer:	Classroom Equipment: smartboard, laptops, calculators, mapping software, infrared Thermometers

		https://www.globe.gov/documents/348614/57388c8d-4774-422c-a104-ba72012d7a66 Urban Heat Island Effect (readings) https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation NASA | Urban Heat Islands (video) https://www.youtube.com/watch?v=s9tMC_80qRQ		
NASA System Engineering Behaviors (2 behaviors per category)	Category (must have one Technical Acumen)	Activities How will student model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes How will you assess learning for each behavior	Evaluation Describe specific science content students understand as a result of engineering behavior.
Listens effectively and translates information	Communications	Students will break up in to teams to identify various samples areas to take surface temperature measurements with rationales.	Works cooperatively with team mates	
Communicates effectively through personal interaction	Communications	Each student will be expected to actively participate in taking measurements and notes	Completes the lab assignment successfully with group members	
Builds Team Cohesion	Leadership	Students must work together to complete the lab	Students assign roles to each other and are responsible for individual task completion as well as the lab as a whole	
Appreciates/Recognizes Others	Leadership	The team aspect of the activity helps students recognize others and the information they offer	Students acknowledge each person's participation	
Remain inquisitive and curious	Attitudes & Attributes	The desire to complete the activity and complete the lab activity should lend itself to keeping the students curious.	Students formulate questions	
Seeks information and uses the art of questioning	Attitudes & Attributes	The students should be utilizing their phones, handouts and each other as information sources	Utilizes the resources given and also uses internet searches to help each other	
Remains open minded and objective	Systems Thinking	Students use the science and data collected to form conclusions and are willing to be flexible in applying what they have learned	Is willing to adjust answers and identifications as new information rises	
Keeps the focus on mission requirements	Systems Thinking	Students ensure that all data sets are complete so that their lab is comprehensive	Stays on task	

Learns from success and failures	Technical Acumen	Students attempt multiple trials at data collection and complete an error analysis to understand how to improve protocols.	Is willing to adjust answers	
List and attach all supportive documents for instructional activities	Attachments? (circle) Yes or No	List Attached Documents(if any): Surface Temperature Lab and Answer Key		
List and attach all rubrics for activity and assessment evaluation	Attachments? (circle) Yes or No	List Attached Rubrics (if any): Surface Temperature Lab Rubric		
Include comments or questions here:				

4. Mission Alignment
   This lesson is aligned with ECOSTRESS, Landsat and Terra.

5. Time to implement lesson: 2 days

6. Materials required
   - Surface Temperature Lab and Answer key
   - Infrared thermometers
   - NASA Resources:
     Surface Temperature Training:
     https://www.globe.gov/web/surface-temperature-field-campaign

     Surface Temperature Protocol
     https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

     Teacher Guide:
     https://www.globe.gov/documents/2981444/3462601/STFC-TeacherParticipationGuide.pdf

     Surface Temperature Data Sheet:
     https://www.globe.gov/documents/348614/57388c8d-4774-422c-a104-ba72012d7a66

     Urban Heat Island Effect (readings)

     https://earthobservatory.nasa.gov/images/86440/vegetation-limits-city-warming-effects

     https://earthobservatory.nasa.gov/images/6800/new-york-city-temperature-and-vegetation

     NASA | Urban Heat Islands (video)
     https://www.youtube.com/watch?v=s9tMC_80qRQ

7. 5 E lesson model template:

Lesson Title: Measuring Surface Temperature
Grade Level: 11th and 12th grades
Duration: One day field trip, with one day follow up
Teacher pre-requisite training: GLOBE protocol training and GLOBE toolkits.
GLOBE Training (https://www.globe.gov/get-trained/protocol-etraining) should be done as far in advance as possible via Globe website.

Surface Temperature Training:
https://www.globe.gov/web/surface-temperature-field-campaign

[Surface Temperature Protocol](https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5)
https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

Teacher Guide:
https://www.globe.gov/documents/2981444/3462601/STFC-TeacherParticipationGuide.pdf

Surface Temperature Data Sheet:
https://www.globe.gov/documents/348614/57388c8d-4774-422c-a104-ba72012d7a66

	What the Teacher Does	**What the Students Do**	**Duration**
Engage: Pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.	Direct students to review their notes from the Urban Heat Island. Students will determine if buildings, asphalt, etc increase the surface temperature through investigation Teacher can provide a recap on climate change https://climate.nasa.gov/vital-signs/global-temperature/	Review areas around the high school campus that students might hypothesize have different surface temperatures.	20 mins
Explore: The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.	The teacher sets the students to map/diagram an area on the school campus that can address how we can examine the urban heat island effect. Teacher should encourage students to look at sample areas with different covers (asphalt, vegetation, heavy traffic areas, etc).	Students will, within their group, locate, identify, sketch and explain why they picked each area around the school campus.	1.5 hours
Explain: Provide students with an opportunity to communicate what they have learned so far and figure out what it means.	The teacher facilitates discussions about surface cover, cloud cover, referencing materials that were presented to reinforce the concept. Teacher allows groups to share out their ideas and answers.	Working in groups, students hypothesize what they will find in terms of difference in surface temperatures. They will hypothesize what might affect surface temperature differences, in addition to surface cover, and predict what kinds of differences they will find. The hypotheses and predictions are based on what they have just learned about the Urban Heat Island Effect.	45 mins

Elaborate / Extend: **allow students to use their new knowledge and continue to explore its implications.**	** Teacher gets trained in globe.gov so that GLOBE protocols can be followed and measurements and data can be uploaded to the GLOBE database. GLOBE Training (https://www.globe.gov/get-trained/protocol-etraining) should be done as far in advance as possible via Globe website. *** GLOBE toolkit link located here (https://www.globe.gov/documents/10157/380993/Tool+Kit) Surface Temperature Training: https://www.globe.gov/web/surface-temperature-field-campaign Surface Temperature Protocol https://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5 Teacher Guide: https://www.globe.gov/documents/2981444/3462601/STFC-TeacherParticipationGuide.pdf Surface Temperature Data Sheet: https://www.globe.gov/documents/348614/57388c8d-4774-422c-a104-ba72012d7a66	Students map out where they want to collect surface temperature data. Students practice using the Infrared Temperature Thermometers (IRT) to take surface temperatures of three samples areas, Students will analyze their data and answer the lab questions once they return to the lab. The data needs to be consolidated with the map. Students will compare and contrast their data with the other groups and, based on the data, draw some conclusions to explain their data and any similarities/differences with other groups.	1 hr 1 hr
Evaluate: **Both students and teachers to determine how much learning and understanding has taken place.**	Teacher will evaluate the students' selection of sample areas and their rationale of why they selected those areas. Teachers will evaluate the labs and answers and analysis and conclusions. Teacher will evaluate students' lab protocols and their analysis and explanation of data, going group by group	Students will review the consolidated map with surface temperatures and draw conclusions based on data. Students will write a comprehensive lab on their findings. Students must be able to explain their data and present it to the rest of the class.	30 mins 45 mins

8. NGSS standards, State science standards and Common Core standards utilized in lesson.

   HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

   HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

   HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on

   Common Core Standard: RST.11.12; HSS.IC.A.2
   Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

   Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

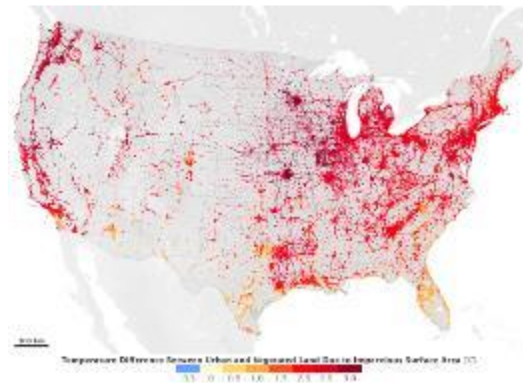
   Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

9. NASA System Engineering Behavior Model utilized in lesson
   - https://www.nasa.gov/pdf/291039main_NASA_SE_Behavior_Study_Final_11122008.pdf

10. Supporting Documents

Surface Temperature Lab

Pre-lab preparation:



1. Look at the school campus. In your group, select three sample areas you may want to find the surface temperature of.

2. What factors affect surface temperature?

3. What is your prediction of what you will find in each of your sample areas, relative to each of your selected locations? Explain your rationale behind these predictions.

Materials: hand-held Infrared Thermometer (IRT), clipboard, lab, tape measure, watch, pen/pencil.

1. Draw a map of your location. Be sure to use a key to indicate building, roads, areas of high traffic, bus stops, construction zones.
2. Using the GLOBE protocols, you will take the surface temperature of three sample areas. For each sample area, you will take three measurements.
3. Be sure to take into account that you want to measure different land covers for comparison purposes (asphalt, concrete, grass, bushes, etc.). Keep in mind what we have learned from the Urban Heat Island Effect and how different land covers affect temperature.

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Map of Area (include a scale)	**Observations of Area** (your location relative to surroundings, such as high-traffic areas, sewage processing plant, highway, apartment buildings, etc.:
Looking up—sky color and visibility, cloud cover 1. What is in your sky (no clouds, few <10%, isolated 1-025%, scattered 25-50%, broken 50-90% or overcast 90%)? 2. Is your sky obscured (fog, heavy rain or snow, smoke, dust, etc) 3. Sky color (deep blue, blue, light blue, pale blue): 4. Sky visibility (clear, somewhat hazy, very hazy, extremely hazy): 5. High level clouds? Mid-level clouds? Low level clouds?	**Surface conditions** How are the surface conditions? (wet, dry, damp, snow, muddy): Air temperature: Relative Humidity: Barometric pressure

Sample #	**Surface Temperature ('C) Reading #1**	**Surface Temperature Reading #2**	**Surface Temperature Reading #3**	**Average Surface Temperature ('C)**	**Observations specific to the sampled area (near vegetation (what kind), water source, street, traffic, lamp post, sewer, etc)**
1					
2					
3					

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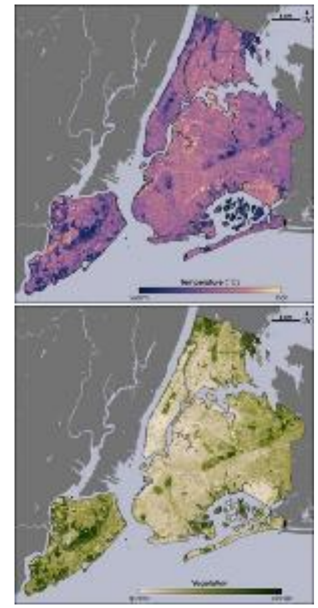
Questions (4 points each):

1. Why is it important to take more than one surface temperature reading per sample?



2. Why is it important to take temperatures of more than one sample area?

3. Why is it essential to note weather conditions?

4. Why do we make observations of the surrounding area?

5. What conclusions can you draw about factors that affect surface temperature?

6. Explain the Urban Heat Island Effect.

7. Explain whether your results support the Urban Heat Island Effect.

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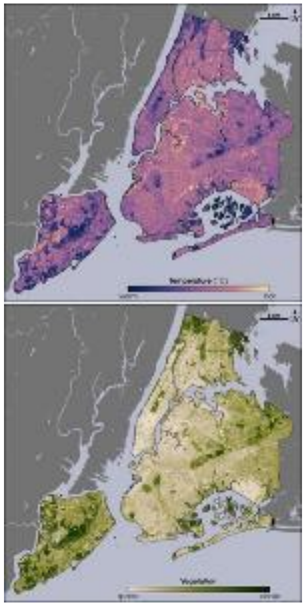
ANSWER KEY

Questions (4 points each):



1. Why is it important to take more than one surface temperature reading per sample?

Taking multiple measurements ensures that we take into account equipment or human error and increases accuracy.

2. Why is it important to take temperatures of more than one sample area?

We are taking samples of different types of surface for comparison purposes. This way, we can draw conclusions and contrast and compare.

3. Why is it essential to note weather conditions?

Weather conditions affect land surface temperature. For example, clouds will decrease land surface temperature, whereas a bright, sunny day might increase land surface temperature.

4. Why do we make observations of the surrounding area?

By taking into account the surrounding area, we can determine of these elements might affect surface temperature. For example, if the selected sample area is right by a road, highway, or heavily traveled path, it may or may not affect surface temperature.

5. What conclusions can you draw about factors that affect surface temperature?

Answers may vary.

6. Explain the Urban Heat Island Effect.

An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The difference in temperature between urban and less-developed rural areas has to do with how well the surfaces in each environment absorb and hold heat.

7. Explain whether your results support the Urban Heat Island Effect.

Answers may vary.

The GLOBE Program: Global Learning and Observations to Benefit the Environment

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Measuring Surface Temperature Rubric

Measurements (part 1—total of 48 points)

3 — observations/measurement taken, using proper scientific terminology, thorough descriptions & details **2** — observations/measurement taken, with some descriptions and details **1** — observations/measurement taken, missing specific descriptions **0** — no measurements taken	Points earned
1. Map of the Area (a maximum score of 3 requires that a scale is included)	
2. Observations of mapped area (a maximum score of 3 must include observations of surrounding area)	
3. Surface temperature of sample 1 (average of 3 readings)	
4. Surface temperature of sample 2 (average of 3 readings)	
5. Surface temperature of sample 3 (average of 3 readings)	
6. Observations specific to sample area 1	
7. Observations specific to sample area 2	
8. Observations specific to sample area 3	
9. What is in your sky (cloud cover)?	
10. Is your sky obscured?	
11. Sky color	
12. Sky visibility	
13. Surface conditions	
14. Temperature	
15. Relative humidity	
16. Barometric Pressure	
TOTAL POINTS	

Part 1 Total______ (48 points possible) **Part 2 Total______ (28 points possible)**

Total points earned (Part 1 + Part 2)_____________/76 possible points = _________________%

Discussion Prompts

1) Why is it important to map put your area before going out into the field?
2) Why is it important to take multiple measurements?
3) Why is it important to sample different types of surfaces?
4) How does land surface temperature relate back to the urban heat island effect?

Discussion Prompts—possible answers

1) Why is it important to map put your area before going out into the field?
   It is important to map out an area before going out into the field so that we can be familiar with the surroundings and be strategic is selecting areas we want to take measurements in. This allows us to be prepared and save valuable time.
2) Why is it important to take multiple measurements?
   Taking multiple measurements is standard practice in science. It ensures that we take into account equipment or human error and increases accuracy.
3) Why is it important to sample different types of surfaces?
   We are taking samples of different types of surface for comparison purposes. This way, we can draw conclusions and contrast and compare.
4) How does land surface temperature relate back to the urban heat island effect?
   Impervious surfaces, such as those found in buildings roads, like concrete and asphalt, increase surface temperature, which contributes to the urban heat island effect. Vegetation is thought to decrease surface temperatures.

Differentiated instruction activities

- Students are grouped heterogeneously based on reading and writing levels
- Students are assigned different levels of reading
- Presentation of information is multimodal and heavily supplemented with illustrations
- Students are asked a range of questions, representing lower and higher-level questions (What, why, how?)
- Students are working at different speeds and at different levels on what they can understand. Materials are supplemented
- Students will be able to take on different roles in the group when working on the lab (data recorder, observer, data analysis, etc).
- Highly interactive lab that incorporates multiple entry points

11. Conclusion and overview of linkages to next lesson and unit goals.

This lesson gives students an overview of factors that affect surface temperature. It also provided students with an opportunity for field work. This leads into the capstone lesson where students are combining what they learned about surface temperatures, urban heat island effect and the wetland ecosystems in exploring a local saltmarsh.

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative Applied Research STEM Curriculum Portfolio

CCRI Unit Plan Template

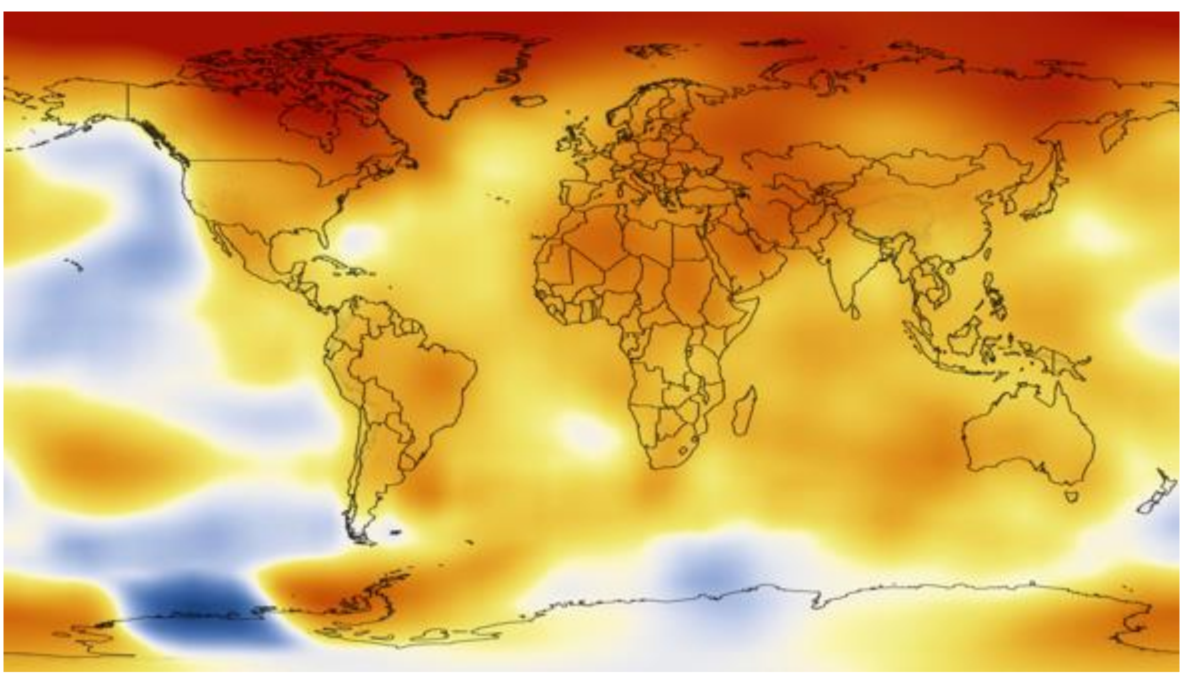
NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

Unit Title: Blue Carbon
Bringing Field Research and ArcGIS Mapping to the High School Classroom

Capstone Project: *How much carbon is there?*
(Project Plan Development and Field trip)

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



XVI. Capstone Project: How much carbon is there?

1. Table of Contents for lesson

2. Summary and Goals of Lesson

By designing their protocols and methods, students have a greater stake in the experiment. They will also learn the process of revising and adjusting their methodology. This leads directly into executing their plan to begin their experiment of coring.

3. CCRI Lesson Plan Content Template

NGSS Standard:	Common Core Standard: RST.11.12; HSS.IC.A.2	NASA Science:
HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity **Phenomenon:** Carbon Cycling Urban Heat Islands **Crosscutting concepts:** Patterns Cause and Effect Systems & System Models Stability and Change	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3) **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3) **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on	Earth Science

		the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)		
Content Area: Environmental Science/Science Research Grade Level: 11th and 12th grades	Name of Project-Based Activity or Theme: Probing at Alley Pond Saltmarsh			Estimated Time Frame to Complete Lesson: 1 week
Overall Investigation Question(s): How can we determine how much carbon is stored in Alley Pond Saltmarsh, using paleoecological methods?				
Overall Project Description/Activity: Students will design and then carry out their own protocols to probe for depth at a local saltmarsh. Using ArcGIS, students will map the area and using that data in combination with in field measurements, determine an estimate of how much carbon is stored in the sediment.				
Materials Needed to Complete Project : Probes Measuring tape/transect IRT Pens/pencils notepads	Stakeholders: Teachers students	Hyperlinks Used: https://earthdata.nasa.gov/learn/gis	Multimedia/Technology:	Classroom Equipment: Laptops with internet connection
NASA System Engineering Behaviors: (1 behaviors per category)	Category (must have one Technical Acumen)	Activities: How will students model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes: How will you assess learning for each behavior	Evaluation: Describe specific science content students understand as a result of engineering behavior.
Ensures system integrity	Leadership	Students will be processing their samples and collecting data. Even if errors are made, which are inevitable, students must be willing to note them	Students will conduct an error analysis, including human errors, and devise plans for the future.	Students must include erroneous data and any errors that are made.
Communicates effectively through personal interaction	Communications	Students must form a cohesive unit to complete the field tasks, including making observations and taking measurements. Students consult with each other to determine final data to record	Students will be able to work as a unit to follow lab protocols.	The students must all be able to speak to their role in the field and what is being done and why.
Seeks information and uses the art of questioning	Attitudes & Attributes	Students need to ask questions about where to probe and take surface temperature measurements and why.	Students are able to find a variety of locations to retrieve probe measurements and surface temperature measurements	Students are able to compare and contrast data from different groups and ask why data is similar or different.
Validates facts, information and assumptions	Systems Thinking	Students utilize the background information grounded in primary research articles.	Students support their findings with science and fact.	Students cite primary literature and appropriate, reliable sources.

Learns from success and failures	Technical Acumen	Students will be processing their samples and collecting data. Even if errors are made, which are inevitable, students must be willing to note them	Students will conduct an error analysis, including human errors, and devise plans for the future.	Students must include erroneous data and any errors that are made.
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes	List Attached Documents(if any): Probing for Depth Handout CCRI PowerPoint Setting up ArcGIS Teacher Guide		
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes	List Attached Rubrics (if any): Probing for Depth Project Development Rubric		
Include comments or questions here:				

4. Mission Alignment
   This lesson plan is aligned with Landsat, Terra and ECOSTRESS

5. Time to implement lesson: 1 week

6. Materials required.

   a. Google Earth Pro
   b. ArcGIS
   c. How much carbon is there? Handout and project development guide.
   d. CCRI PPT

7. 5 E lesson model template:

Lesson Title: Probing depth
Grade Level: 11th and 12th graders
Duration: one week

*** This lesson can apply to any wetland in the United States. To modify this lesson for any wetland in any area, teachers can go to the Wetlands Mapper, https://www.fws.gov/wetlands/data/Mapper.html, which is a part of the National Wetlands Inventory provided by the US Fish and Wildlife Service. Teachers can find local wetlands nearby their school for a daytrip. Additionally, the National Environmental Education Foundation lists United Wetlands by state (https://www.neefusa.org/nature/land/wetlands-united-states, which links back to the US Fish and Wildlife Service with specific wetlands in that state. The site provides highlights of what fauna and flora are found in each of the wetlands.

	What the Teacher Does	**What the Students Do**	**Duration**
Engage: Pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.	Share the following articles with student on Dr. Dorothy Peteet: https://blogs.ei.columbia.edu/2018/12/19/tools-bog-coring-peteet/ https://www.wamc.org/post/dr-dorothy-peteet-columbia-university-hudson-river-and-climate-records https://www.nytimes.com/2020/03/05/climate/shinnecock-long-island-climate.html https://www.nytimes.com/2005/11/06/nyregion/climate-in-a-marsh-sifting-the-past-and-seeing-the-future.html NASA's Goddard of Space Studies Sea Level Rise Seminar https://www.youtube.com/watch?v=awUArN2dFew	Read the articles, listen to the short interview. View PowerPoint slides from NASA's Climate Change Research Initiative Research	25 minutes

	Show PowerPoint slides from NASA's Climate Change Research Initiative Research Share with the students how we probe for depth. (Chimney rods can be purchase at local hardware stores and can be attached to extend the length) Pre-planning for a field trip is also recommended. Elicit that we can find volume of carbon with depth x area.		
Explore: **The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understandin g.**	Ask students to explore how we as a class can do the same. Elicit suggestions to probe at Alley Pond saltmarsh. (or a local saltmarsh/wetland) Teacher elicits that mapping needs to be done before heading out into the field. Teacher elicit answers such as types of plants, and animals seen, cloud cover, nearby human impact.	Brainstorm ways to probe for depth and what research needs to be done before going out into the field. (using household tools perhaps and keeping in mind budgetary constraints. Students should also ask what other observations we can make while we are out in the field.	1 hour
Explain: **Provide students with an opportunity to communicat e what they have learned so far and figure out what it means. EXPL AIN**	Instruct students to develop materials and methods/procedures.	Students will develop the materials and methods protocol as suitable for the classroom, drawing on what they've learned in class Students come to one consensus on a class protocol to core, including map assignments for each group and assignments for each team member	1 hour

Elaborate / Extend: **allow students to use their new knowledge and continue to explore its implications.**	Plan a trip to Alley Pond for probing (or a local wetland) Remind students to print out a map of where they are probing, and create and print a hardcopy for notetaking (coordinates, depth).	Students will decide on different areas of the marsh to probe. Include materials and protocol for including locating and identifying distance between transects.	1 hour
Evaluate: **Both students and teachers to determine how much learning and understanding has taken place.**	Teacher evaluates project plan as well as the role each student has.	Students share out their plan with other groups. Revise and revisit to create one class plan. Students will be prepared to explain their methods and procedures and be receptive to constructive criticism. Students need to address challenges and ways in which to address them.	1 hour

8. NGSS standards, state science standards utilized in lesson

HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Common Core Standard: RST.11.12; HSS.IC.A.2
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

9. NASA System Engineering Behavior Model utilized in lesson

Validates facts, information and assumptions, learns from success and failures, builds team cohesion,

10. Supporting Documents

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Teacher preparation

Before the Unit:

What is GIS

GIS stands for Geographic Information System. To see how NASA uses GIS, refer to
https://earthdata.nasa.gov/learn/gis

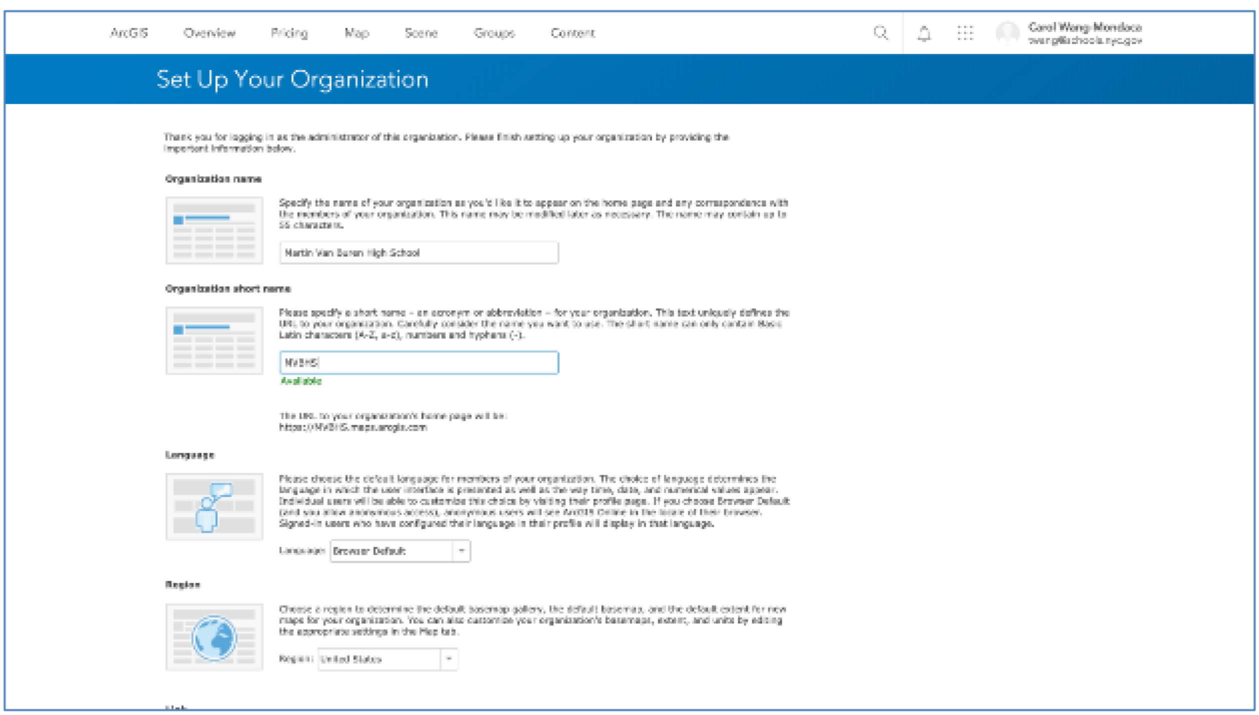
What is ArcGIS:

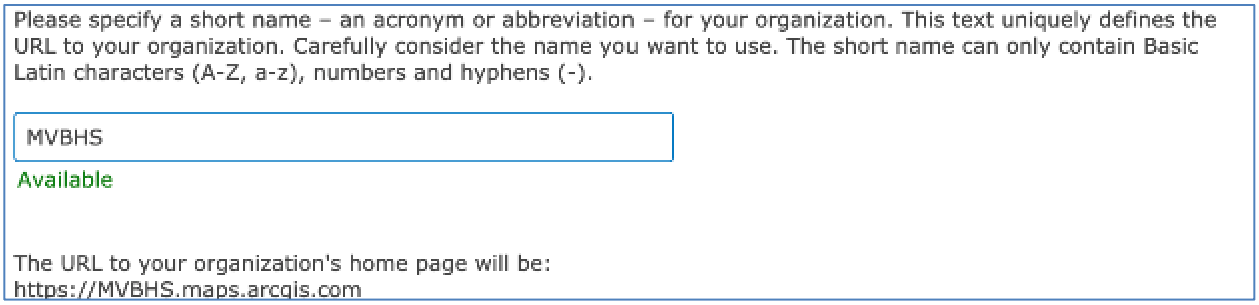
ArcGIS Online is a cloud-based mapping, analysis, and data storage system hosted by Esri that can be used to create, share, and manage maps, scenes, layers, apps, and other geographic content.

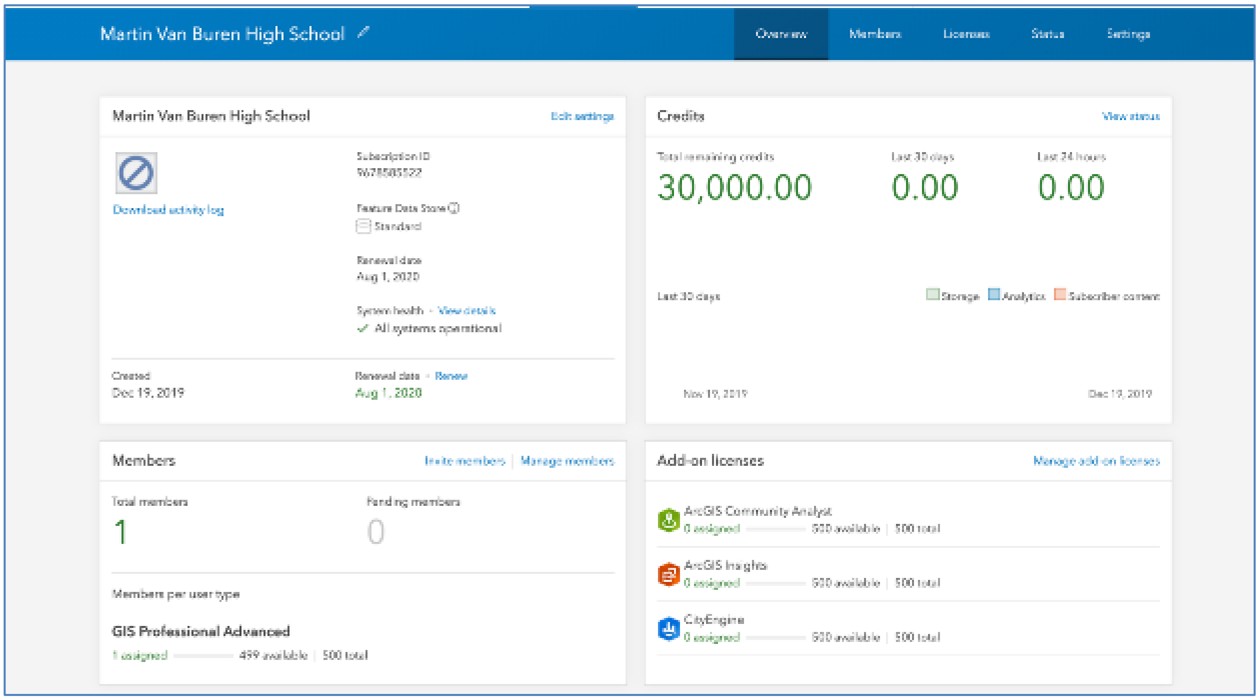
Getting Started with ArcGIS Online Resources

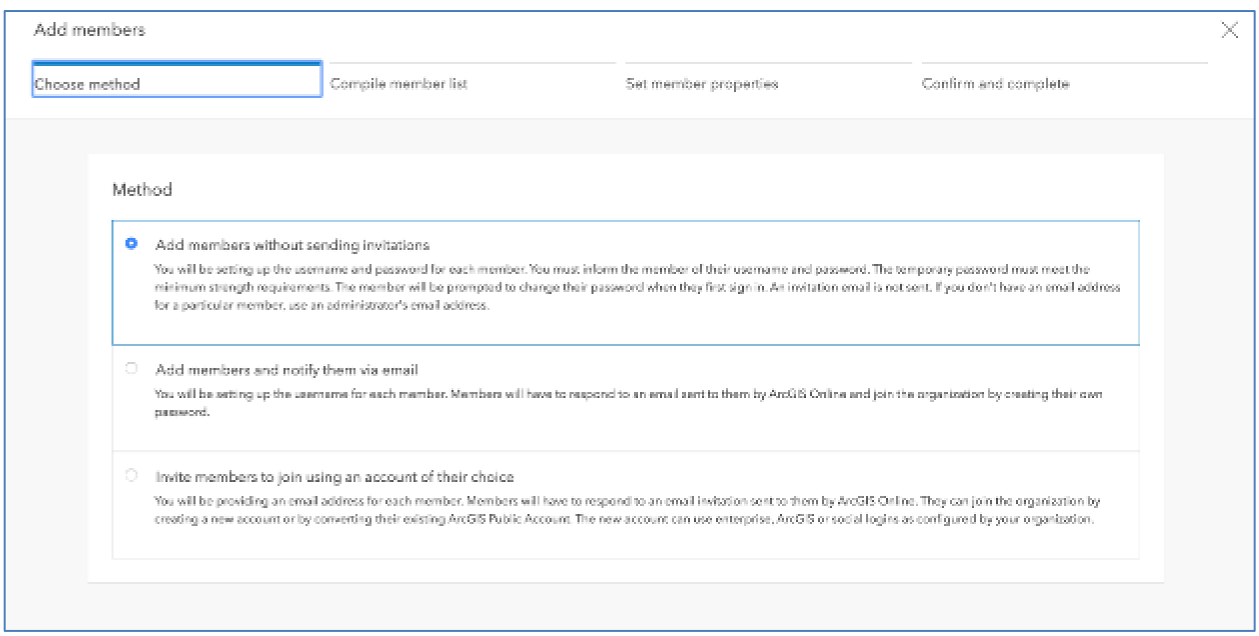
ESRI ArcGIS online (organizational account) is free for K-12 schools. Request an ArcGIS for Schools Bundle Account at:
http://www.esri.com/industries/education/software-bundle#

You will then receive an email with a link to activate the account. You'll have a subscription ID number, customer number and your school name will be linked.




Please specify a short name – an acronym or abbreviation – for your organization. This text uniquely defines the URL to your organization. Carefully consider the name you want to use. The short name can only contain Basic Latin characters (A-Z, a-z), numbers and hyphens (-).
MVBHS
Available
The URL to your organization's home page will be:
https://MVBHS.maps.arcgis.com


Martin Van Buren High School
Overview
Members
Licenses
Status
Settings
Martin Van Buren High School
Edit settings
Download activity log
Subscription ID
Feature Data Store
Standard
Renewal date
Aug 1, 2020
System health · View details
All systems operational
Created
Dec 19, 2019
Renewal date · Renew
Aug 1, 2020
Credits
View status
Total remaining credits
30,000.00
Last 30 days
0.00
Last 24 hours
0.00
Last 30 days
Storage
Analytics
Subscriber content
Nov 19, 2019
Dec 19, 2019
Members
Invite members
Manage members
Total members
1
Pending members
0
Members per user type
GIS Professional Advanced
1 assigned
499 available | 500 total
Add-on licenses
Manage add-on licenses
ArcGIS Community Analyst
0 assigned
500 available | 500 total
ArcGIS Insights
0 assigned
500 available | 500 total
CityEngine
0 assigned
500 available | 500 total


Add members
Choose method
Compile member list
Set member properties
Confirm and complete
Method
Add members without sending invitations
You will be setting up the username and password for each member. You must inform the member of their username and password. The temporary password must meet the minimum strength requirements. The member will be prompted to change their password when they first sign in. An invitation email is not sent. If you don't have an email address for a particular member, use an administrator's email address.
Add members and notify them via email
You will be setting up the username for each member. Members will have to respond to an email sent to them by ArcGIS Online and join the organization by creating their own password.
Invite members to join using an account of their choice
You will be providing an email address for each member. Members will have to respond to an email invitation sent to them by ArcGIS Online. They can join the organization by creating a new account or by converting their existing ArcGIS Public Account. The new account can use enterprise, ArcGIS or social logins as configured by your organization.

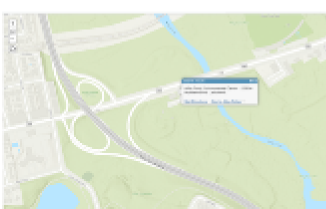
Probing at Alley Pond Saltmarsh: Project Plan Development & Field Study

Design a research plan to probe for depth at Alley Pond Park.

You must:

1) Develop the materials and methods. Include all materials you will need. Keep in mind our budget. You may be creative in your selection of materials or adjustment/modification of existing materials, such as household items.
2) You must include safety protocols in your outline, especially since we will be in water saturated areas with slippery areas near bodies of water that may not have easily accessible access points.
3) As you develop your plan, keep in mind the specific data we will want to collect, on site, as well as in the lab after we bring samples back. (On site data collection might include simple items such as weather, tide level, cloud cover, and location). You should also be noting what kind of observations you will be making.

4) Part of your pre-planning was determining where you were going to probe. You should bring a copy of your map and create a chart of observations you might want to make while we are onsite regarding your probe site.
5) As you develop your materials, think about the process of transporting our equipment to the site, the note taking process, as well as bringing the equipment back.
6) Your team must work together and take equal ownership of the plan. Pick your team mates carefully.

Plan Category	Draft	Revision
1. Materials Include materials that need to be made or purchased (keep in mind our budget) 		
2. Methods Include location, safety protocols. You must map out your location beforehand. 		

Plan Category	Draft	Revision
3. Data to be collected (includes data @ the site as well as data that will be calculated in the lab)  *Other notes:*		
4. Observations to be made (site observations such as location of your site and vicinity to sewage overflow, human industry, etc., weather, any wetland species you might see, etc.)  *Other notes:*		

<table>
<tr><th>Plan Category</th><th>Draft</th><th>Revision</th></tr>
<tr><td>5. Potential Challenges

(don’t forget to address those challenges with possible solutions/alternatives)

Other notes:</td><td></td><td></td></tr>
</table>

Probing at Alley Pond Saltmarsh

Project Development Rubric

Criteria	Exceeds Standards (4)	Meets Standards (3)	Approaching Standards (2)	Below Standards (1)
1. Materials	The materials are reasonable and logical and demonstrate a deep understanding of the scientific basis of the fieldwork. Budget and accessibility are taken into account.	The materials are reasonable and logical and demonstrate an understanding of the scientific basis of the fieldwork. Budget and accessibility are taken into account.	The materials are somewhat reasonable and logical and demonstrate a superficial understanding of the scientific basis of the fieldwork. Budget and/or accessibility are not taken into account.	The materials are missing or budget and accessibility are not taken into account.
2. Methods outline	The methods demonstrate a deep understanding of the science topic. The outline is logical and reasonable and uses scientific terminology.	The methods demonstrate an understanding of the science topic. The outline is mostly logical and reasonable and uses scientific terminology.	The methods demonstrate somewhat of an understanding of the science topic. The outline is not logical or reasonable and does not use scientific terminology.	The methods are not provided
3. Safety Protocols	Safety protocols take into account all aspects and protocols as it relates to field and lab work.	Safety protocols take into account most aspects and protocols as it relates to field and lab work.	Safety protocols take into account some aspects and protocols as it relates to field and lab work.	No safety protocols are provided.
4. Location selection/mapping	Location selection and mapping demonstrates a deep understanding of the scientific background. Reasoning is logical, accurate and complete. Pre-field mapping is completed.	Location selection and mapping demonstrates somewhat of an understanding of the scientific background. Reasoning is mostly logical, accurate and complete. Pre-field mapping is completed.	Location selection and mapping does not indicate an understanding of the scientific background. Reasoning is illogical and incomplete or inaccurate.	No location selection or pre-field mapping is present.
5. Data to be collected (@ the site)	Data to be collected demonstrates a deep understanding of the context and scientific content. Graphs, tables and visuals are meaningful and selected to heighten the quality of the work.	Data to be collected demonstrates somewhat of an understanding of the context and scientific content. Graphs, tables and visuals are mostly meaningful or have ancillary significance.	Data to be collected demonstrates a cursory understanding of the context and scientific content. Visuals are not completely related to the work and/or do not add to the work.	There is no indication of data to be collected. No visuals, graphs, or tables are used
6. Data to be calculated and analyzed (at the lab)	Data to be analyzed demonstrates a deep understanding of the context and scientific content. Graphs, tables and visuals are meaningful and selected to heighten the quality of the work.	Data to be analyzed demonstrates somewhat of an understanding of the context and scientific content. Graphs, tables and visuals are mostly meaningful or have ancillary significance.	Data to be analyzed demonstrates a cursory understanding of the context and scientific content. Visuals are not completely related to the work and/or do not add to the work.	There is no indication of data to be analyzed. No visuals, graphs, or tables are used

7. Observations to be made	Observations to be collected demonstrates a deep understanding of the context and scientific content. They are meaningful and selected to heighten the quality of the work.	Observations to be collected demonstrate somewhat of an understanding of the context and scientific content. They are mostly meaningful or have ancillary significance.	Observations to be collected demonstrate a cursory understanding of the context and scientific content. They are not completely related to the work and/or do not add to the work.	There is no indication that observations are to be made.
8. Potential challenges	Potential challenges outlined shows a deep understanding of the methods developed and what the field work entails, including data collection, location selection and familiarity with the location.	Potential challenges outlined shows an understanding of the methods developed and what the field work entails, including most aspects of data collection, location selection and familiarity with the location.	Potential challenges outlined shows a superficial understanding of the methods developed and what the field work entails, including some aspects such as data collection, location selection and familiarity with the location.	Potential challenges are not addressed or are illogical and unreasonable.
9. Solution to potential challenges.	Solution to potential challenges are well thought out and logical and reasonable.	Solution to potential challenges are mostly well thought out and mostly logical and reasonable.	Solution to potential challenges are somewhat outlined but are not reasonable or logical.	Solution to potential challenges are not addressed
10. Participation in group	Group members played integral roles and were active participant throughout the project development	Group members mostly were active in participating in project development	Group members played some role in project development	One or more group members did not participate in project development.
11. Proofreading/grammar	Writing uses clear, concise and expressive language. Writing accurately includes scientific terms and vocabulary. Writing is grammatically accurate and error free	Writing uses clear and understandable language. Writing accurately includes scientific terms and vocabulary. Writing is grammatically accurate with some typos.	Writing uses clear and understandable language. Writing uses conventional terminology and vocabulary. Writing has some grammatical errors and typos.	Writing does not use clear and understandable language. Writing uses conventional terminology and vocabulary. Writing has not been proofread.
12. Enthusiasm and effort	Group was animated and enthusiastic while presenting their protocols.	Group was enthusiastic during the presentation of their protocols.	Group showed some enthusiasm.	Group did not show any enthusiasm

Additional Comments:

Total Points (max 48): ______________ (42-48 = exceeding; 34-41 meeting; 30-33 approaching; <29 below))

Discussion Prompts

- What are your observations?
- What conclusions can you draw based on your findings?
- What further research might you have to do?
- What are your next steps?

Discussion Prompts~ suggested answers

- What are your observations?
  - Student answers will vary but should be compared to what is normal for the area. Students may answer in relative terms, such as certain areas are deeper than others. They may also observe characteristics of the area.
- What conclusions can you draw based on your findings?
  - Depth varies at various spots.
- What further research might you have to do?
  - Repeat the trial, increase the sampling size by investigating other bodies of water nearby.
- What are your next steps?
  - Draw conclusions based on the data and design a next experiment.

Differentiated instruction activities

- Students are grouped heterogeneously based on reading and writing levels
- Students are assigned different levels of reading
- Presentation of information is multimodal and heavily supplemented with illustrations
- Students are asked a range of questions, representing lower and higher-level questions (What, why, how?)
- Students are working at different speeds and at different levels on what they can understand. Materials are supplemented
- Students will be able to take on different roles in the group when working on the lab (data recorder, observer, data analysis, etc).
- Highly interactive lab that incorporates multiple entry points

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

NASA Climate Change Research Initiative Applied Research STEM Curriculum Portfolio

CCRI Unit Plan Template

NASA Science Mission Directorate | Earth Sciences Division
NASA Goddard Institute for Space Studies
NASA Goddard Space Flight Center | Office of STEM Engagement

Unit Title: Blue Carbon

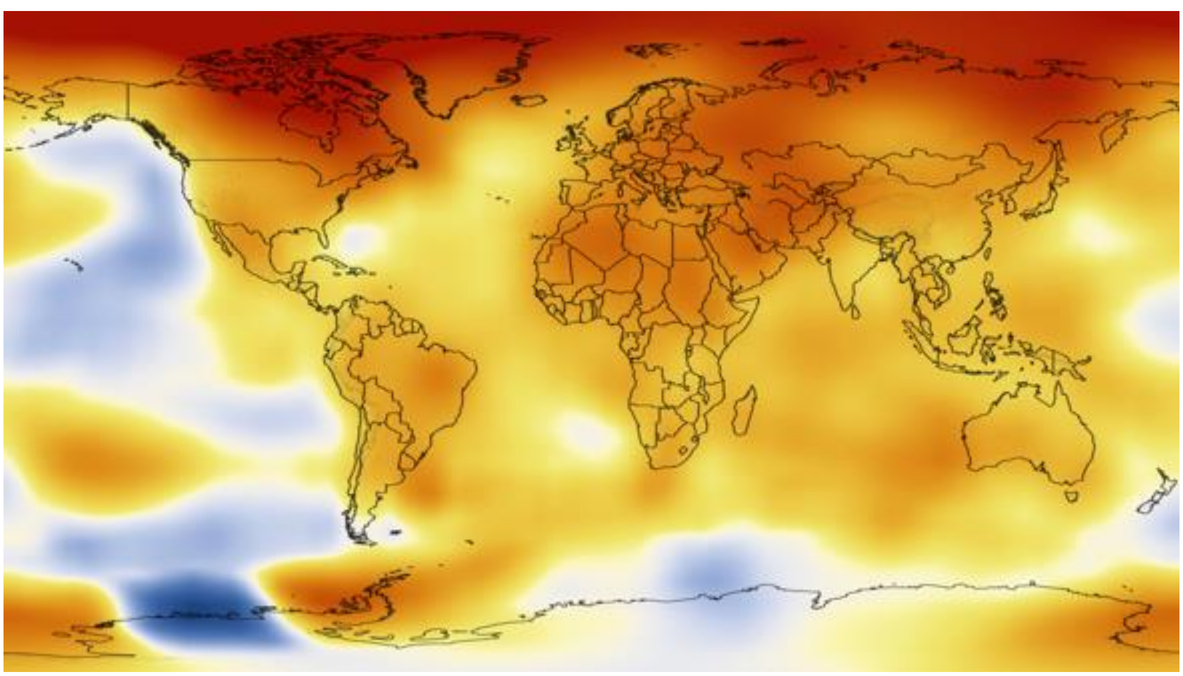
Bringing Field Research and ArcGIS Mapping to the High School Classroom

ALTERNATIVE CAPSTONE

Capstone Project: *Blue Carbon Story Map*

NASA STEM Educator / Associate Researcher: Carol Wang-Mondaca

NASA PI / Mentor: Dr. Dorothy Peteet



XVII. ALTERNATIVE Capstone Project: Blue Carbon Story Map

1. Table of Contents for lesson

2. Summary and Goals of Lesson

This project is a summation of the subtopics that students learned throughout the unit. They will incorporate the resources they have used, especially ArcGIS for mapping and complete a Story Map. This project is intended to emphasize that wetlands and Blue Carbon are global and by having students research wetlands in their home country or a location of significance to them, it incorporates student buy in, student choice, as well as diversity and inclusion.

3. CCRI Lesson Plan Content Template

NGSS Standard:	Common Core Standard: RST.11.12; HSS.IC.A.2	NASA Science:
HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity **Phenomenon:** Carbon Cycling Urban Heat Islands **Crosscutting concepts:** Patterns Cause and Effect Systems & System Models Stability and Change	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3) **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3) **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple	Earth Science

			sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)	
Content Area: Environmental Science/Science Research Grade Level: 11th and 12th grades	Name of Project-Based Activity or Theme: Blue Carbon Story Map			Estimated Time Frame to Complete Lesson: 1 week
Overall Investigation Question(s): How can we create an ArcGIS Story Map of Blue Carbon				
Overall Project Description/Activity: Students will design their own ArcGIS Story Map. Using ArcGIS, students will need to incorporate all the resources they have learned and used up to this point, including mapping with layers, outlining the importance of wetlands, the significance of blue carbon.				
Materials Needed to Complete Project : ArcGIS subscription Computer	Stakeholders: Teachers students	Hyperlinks Used: https://earthdata.nasa.gov/learn/gis https://storymaps.arcgis.com/stories/cea22a609a1d4cccb8d54c650b595bc4	Multimedia/Technology:	Classroom Equipment: Laptops with internet connection
NASA System Engineering Behaviors: (1 behaviors per category)	Category (must have one Technical Acumen)	Activities: How will students model engineering behaviors when learning science content? Describe student activities here.	Student Outcomes: How will you assess learning for each behavior	Evaluation: Describe specific science content students understand as a result of engineering behavior.
Ensures system integrity	Leadership	Student will complete project in a timely manner and respect the deadlines. Students will offer each other help on resources	Students collaborate to share resources and submit their work on time.	
Uses visuals to communicate complex interactions	Communications	Students will need to use multimodalities to present their Story Maps and must be able to communicate the rational for their choices	Students include different forms of presentation to communicate their story. (text, verbal, graphics).	
Seeks information and uses the art of questioning	Attitudes & Attributes	S student explore NASA resources and ArcGIS Maps to find appropriate information	Students are able to build on the Story Map and address the elements in the rubric	
Validates facts, information and assumptions	Systems Thinking	Students must find valid information and support their text with graphs and maps.	Students will include appropriate graphics and illustrations and maps to support their text	
Learns from success and failures	Technical Acumen	Peer review and teacher review of Story Maps		

			Students accept constructive criticism and are able to make changes and adjustments in response	
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes	List Attached Documents(if any): Creating an ArcGIS Story Map PPT Creating an ArcGIS Story Map handout		
List and attach all PowerPoint presentations and supportive documents for instructional activities	Attachments? Yes	List Attached Rubrics (if any): Creating an ArcGIS Story Map Rubric		
Include comments or questions here:				

4. Mission Alignment
   This lesson is aligned with Landsat and ECOSTRESS.

5. Time to implement lesson: 2 weeks

6. Materials required
   a. ArcGIS

7. 5 E lesson model template:

Lesson Title: ArcGIS Story Map of Blue Carbon
Grade Level: 11th and 12th graders
Duration: one week

	What the Teacher Does	**What the Students Do**	**Duration**
Engage: Pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.	Explain that students will have the opportunity to create their own Story Map. This project is ideal for remote situations and students will have the opportunity to feature their work. They will get to select a location of interest to them. This is an excellent opportunity to highlight Diversity & Inclusion.	Beginning brainstorming what area they want to map out and research. Students should review existing Story Maps or visit the Urban Heat Island Story Map to recall what information is included.	45 minutes

Explore: **The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.**	Teacher direct students to gather their information and determine the elements of how they want to tell their story (including what order and what topics they want to include) https://storymaps.arcgis.com/stories/cea22a609a1d4cccb8d54c650b595bc4 Provides guidance to students on how to get started	Students begin by reviewing how to build a Story Map https://storymaps.arcgis.com/stories/cea22a609a1d4cccb8d54c650b595bc4 Students should explore what NASA map base layers can be added.	1 hour
Explain: **Provide students with an opportunity to communicate what they have learned so far and figure out what it means. EXPLAIN**	Teacher directs students to follow rubric so that they are covering and explaining all items for the project.	Students build their Story Maps	1 hour
Elaborate / Extend: **allow students to use their new knowledge and continue to explore its implications.**	Teacher directs students to add graphics, maps and graphs to help expand on the student stories	Students use maps, graphs and graphics and illustrations to elaborate on their text.	1 hour

Evaluate: Both students and teachers to determine how much learning and understandin g has taken place.	Teacher evaluates project plan as well as the role each student has. Teachers use the same rubric as the student peer review rubric.	Students share their Story Maps and provide constructive criticism to their peers using peer reviewer rubric.	1 hour

8. NGSS standards, state science standards utilized in lesson

HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-ESS3: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Common Core Standard: RST.11.12; HSS.IC.A.2
Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS- LS2-2),(HS-LS2-3)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on fact

9. NASA System Engineering Behavior Model utilized in lesson

Uses visuals to communicate complex interactions, remains inquisitive and curious and keeps the focus on mission requirements.

10. Supporting Documents

i. Discussion Prompts

How will you determine which wetland to research?
How will you find the resources?
How will you know when you have covered all aspects?
How does your selected wetland tie into your life?

ii. Differentiated instruction activities

This is an independent project that is self-paced by the student. Student can use the video tutorials, written instructions or pictures for guidance.

Teacher preparation

Before the Unit:

What is GIS

GIS stands for Geographic Information System. To see how NASA uses GIS, refer to
https://earthdata.nasa.gov/learn/gis

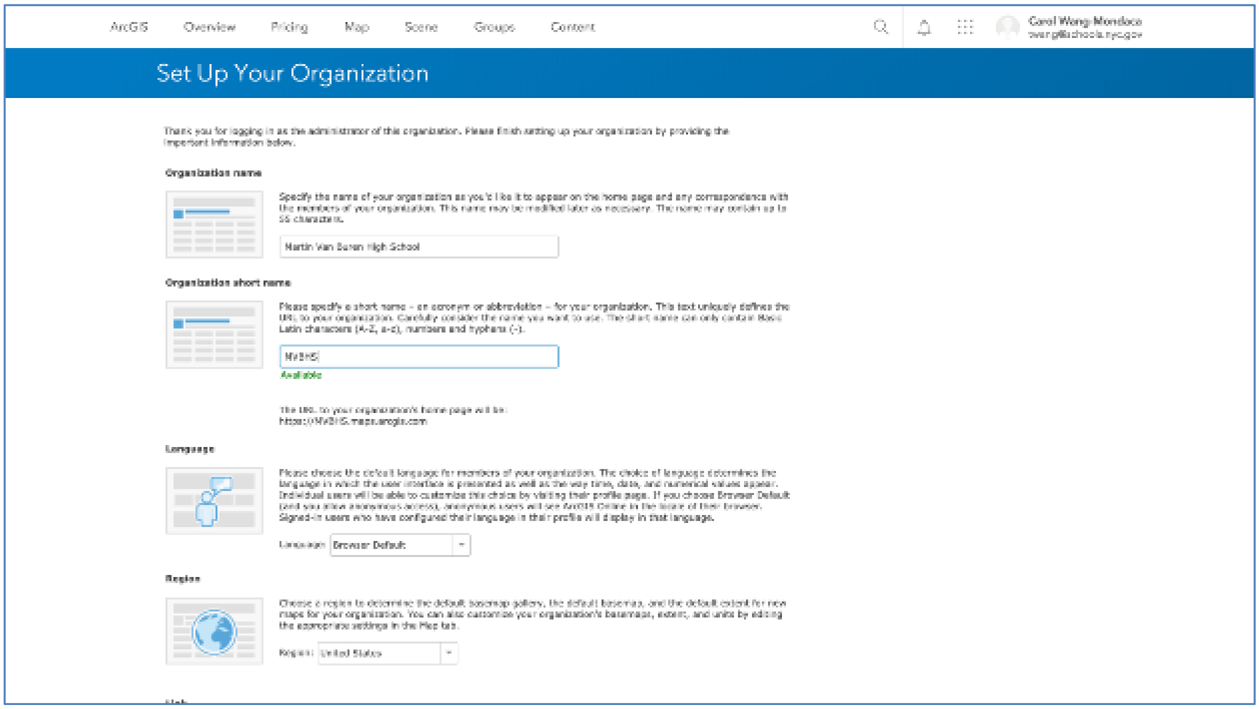
What is ArcGIS:

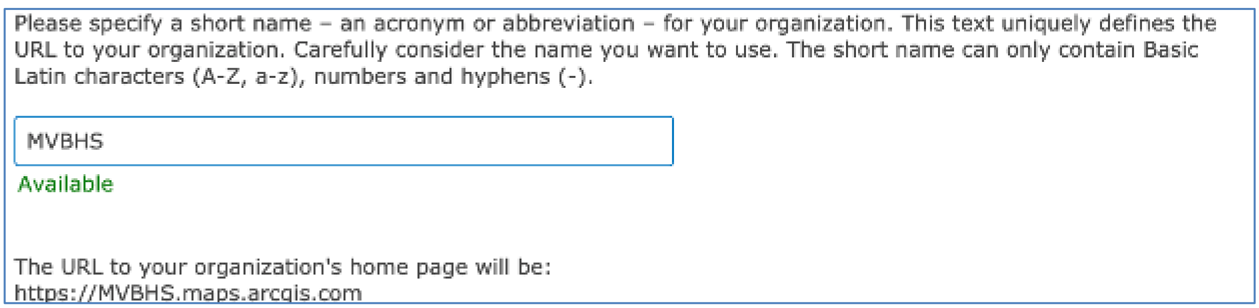
ArcGIS Online is a cloud-based mapping, analysis, and data storage system hosted by Esri that can be used to create, share, and manage maps, scenes, layers, apps, and other geographic content.

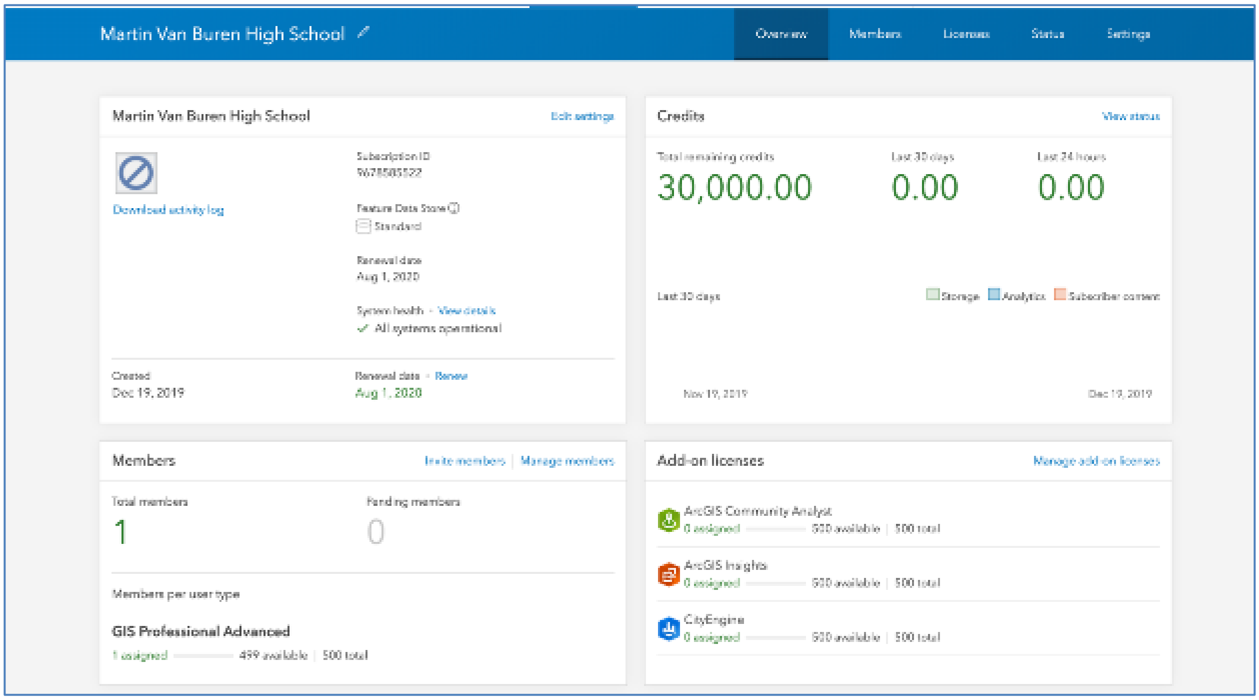
Getting Started with ArcGIS Online Resources

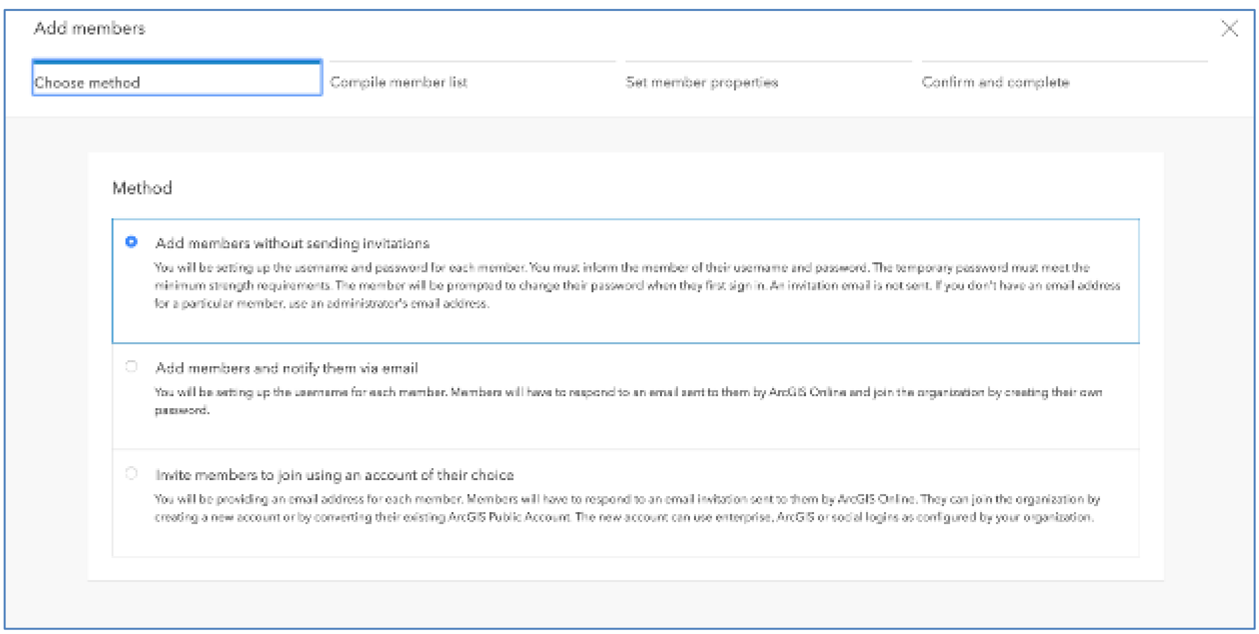
ESRI ArcGIS online (organizational account) is free for K-12 schools.
Request an ArcGIS for Schools Bundle Account at:
http://www.esri.com/industries/education/software-bundle#

You will then receive an email with a link to activate the account. You'll have a subscription ID number, customer number and your school name will be linked.


ArcGIS
Overview
Pricing
Map
Scene
Groups
Content
Set Up Your Organization
Organization name
Martin Van Buren High School
Organization short name
MVBHS
Available
Language
Language: Browser Default
Region
Region: United States


Please specify a short name – an acronym or abbreviation – for your organization. This text uniquely defines the URL to your organization. Carefully consider the name you want to use. The short name can only contain Basic Latin characters (A-Z, a-z), numbers and hyphens (-).
MVBHS
Available
The URL to your organization's home page will be:
https://MVBHS.maps.arcgis.com


Martin Van Buren High School
Overview
Members
Licenses
Status
Settings
Martin Van Buren High School
Edit settings
Download activity log
Subscription ID
Feature Data Store
Standard
Renewal date
Aug 1, 2020
System health · View details
All systems operational
Created
Dec 19, 2019
Renewal date · Renew
Aug 1, 2020
Credits
View status
Total remaining credits
30,000.00
Last 30 days
0.00
Last 24 hours
0.00
Last 30 days
Storage
Analytics
Subscriber content
Nov 19, 2019
Dec 19, 2019
Members
Invite members | Manage members
Total members
1
Pending members
0
Members per user type
GIS Professional Advanced
1 assigned
499 available | 500 total
Add-on licenses
Manage add-on licenses
ArcGIS Community Analyst
0 assigned
500 available | 500 total
ArcGIS Insights
0 assigned
500 available | 500 total
CityEngine
0 assigned
500 available | 500 total


Add members
Choose method
Compile member list
Set member properties
Confirm and complete
Method
Add members without sending invitations
You will be setting up the username and password for each member. You must inform the member of their username and password. The temporary password must meet the minimum strength requirements. The member will be prompted to change their password when they first sign in. An invitation email is not sent. If you don't have an email address for a particular member, use an administrator's email address.
Add members and notify them via email
You will be setting up the username for each member. Members will have to respond to an email sent to them by ArcGIS Online and join the organization by creating their own password.
Invite members to join using an account of their choice
You will be providing an email address for each member. Members will have to respond to an email invitation sent to them by ArcGIS Online. They can join the organization by creating a new account or by converting their existing ArcGIS Public Account. The new account can use enterprise, ArcGIS or social logins as configured by your organization.


Creating an ArcGIS Story Map

1


Blue Carbon Story Map

2


What is Blue Carbon

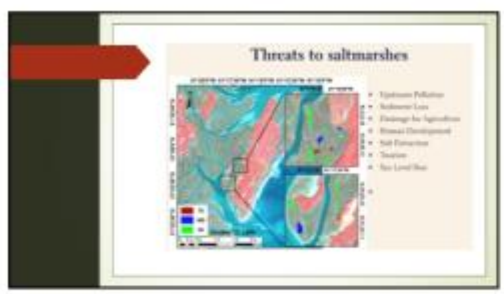
3


Where the wetlands are | Earthdata
Wetlands

4


Jamaica Bay, NY

5


Threats to saltmarshes

6


Why are saltmarshes so important?

7

8


Gaomei Wetlands, Taiwan

9


Patagonian Wetlands, Chile

10

Creating an ArcGIS Story Map

Go to https://storymaps.arcgis.com/stories
Log into your ArcGIS account
Click on + New Story—and you are ready to begin!

You are creating a Blue Carbon Story Map or a Wetlands Story Map. To get an idea of what a Story Map consists of and what is out there, you can visit https://storymaps-classic.arcgis.com/en/gallery/#s=0
.

Here are the ground rules:

1) You must provide background information on marshes, including the ecosystem and economic benefits as well as threats to marshes.
2) You must define Blue Carbon and explain its importance
3) You will then research wetlands in your neighborhood, your home country, some place that you have lived or some place you want to live.
4) You must discuss the state of wetlands and conservation efforts if any
5) You will use all the resources we have been using in class up until now and you will create new maps. You must include at least three different kinds of maps (either locations or map bases or layers). Your Story Map should be heavily illustrated

Some Story Maps worth visiting:
Great Wetlands of the World:
https://story.maps.arcgis.com/apps/MapSeries/index.html?appid=aed61922c4b444ba843d19e676e80004
Blue Carbon Story Map

http://ead.maps.arcgis.com/apps/MapJournal/index.html?appid=1c13a009d5f24f829ffeda78c9cfab00

https://www.arcgis.com/apps/MapJournal/index.html?appid=0767616f0de44cb0ac18c206a67ee8d8

https://www.arcgis.com/apps/MapJournal/index.html?appid=dfa52f8f91754c24804b6d63e782fb7f

National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

Blue Carbon

ArcGIS Story Map

Student Checklist/RUBRIC

Check off as Completed	Item to be Included	Points earned (1-4 scale) 4 exceeds standards 3 meets standards 2 approaching standards 1 below standards
	1) Blue Carbon (16 points) a) Define Blue Carbon (4) b) Provide background information on blue carbon (4) c) Interesting facts and data points (4) d) Illustrations, graphs, maps (4)	a) b) c) d) Total in this section:
	2) Wetlands (20 points) a) What economic and ecosystem services do wetlands provide? (4) b) Why are wetlands threatened? (4) c) Human impact on wetlands? (4) d) What can humans do to restore and conserve wetlands? Why is this important (4) e) Illustrations, graphs, maps (4)	a) b) c) d) e) Total in this section:
	3) Select a wetland location that is significant to you. It can be from your neighborhood, some place you've visited, your home country, some place you would like to visit inf the future, etc. (a guided tour would be appropriate here) (20 points) a) The map is very significant (4) b) Illustrations, graphics (4) c) Describe the wetland (restored, at risk, protected, etc.) (4) d) Provide background information on the wetland (4) e) What are some specific ecosystem services this particular wetland provides? (4)	a) b) c) d) e) Total in this section:
	Other elements (24) a) included a "side car" (4) b) Included a "guided map tour" (4) c) Included at least one map with layers (4) d) Clear Titles, labels, credits provided (4) e) Used at least four NASA resources (4) f) Story Map is free of typos, is proofread and grammatically correct (4)	a) b) c) d) e) f) Total in this section:
	TOTAL SCORE (out of 80 possible points)	

Peer reviewer name: ______________________________

Additional Comments: